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Volume XVI

Edited by

CARLETON REA, J. RAMSBOTTOM, B. F. BARNES
and H. WORMALD

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THE KING'S LYNN FORAY

June 6th–10th, 1930

By E. M. WAKEFIELD

The 1930 Spring Foray was held during the Whitsun week-end at King's Lynn, Norfolk, with headquarters at the Hotel Cozens.

Thanks to the local knowledge of Mr Petch, who very kindly undertook to plan the excursions, the localities visited were such as were likely to prove most interesting at that time of year. It will be noticed from the list that the larger fungi were comparatively scarce, but the microfungi are well represented, especially as to the Rusts and Pyrenomycetes. Mr E. W. Mason was responsible for recording the majority of the Pyrenomycetes given in the accompanying list, while the various species from rabbit dung were notified subsequently by Miss W. M. Page. On the first evening Mr Petch showed various species he had collected just before the foray, including *Arachniotus ruber*, *Urocystis Violae*, and *Polyporus brumalis*. For some of these, as also for some of the Pyrenomycetes, no definite localities are given, but as all were collected in the near neighbourhood of King's Lynn they are given in the list with the letter *K*.

On the first day, Saturday, June 7th, the party proceeded by bus to Bawsey, distant about $2\frac{3}{4}$ miles from King's Lynn. A walk through pine and heather on sand brought them to Holt House Wood, with birch and alder swamp. Here were found *Exoascus Pruni* on *Prunus Padus*, and *Diaporthe patria* on *Pyrus Aucuparia*. After leaving Holt House Wood another short walk brought the party to a strip of woodland north of the Gayton Road, indicated in the list as North Wood (*N.*). One of the earliest finds here was a splendid group of sporophores of *Polyporus varius*, growing on the branches of a fallen, dead tree. *Helvella lacunosa* was also found in this strip of wood, but otherwise little of note.

Sunday was spent partly in Reffley Wood and partly in Black Hills Plantation—both mixed woods. Here the ground was more damp than on the previous day, and a fair number of fleshy fungi were found, including *Boletus reticulatus*, *B. rugosus*, and *B. variegatus*. Two species of *Peronospora* and a fair number of other microfungi indicated the damp character of some of the undergrowth.

On Monday, Leziate Fen and Sugar Fen were worked, the ground covered being chiefly open fen with alder copses, and two fairly old birch and alder woods. The larger fungi were naturally few, but *Russula constans* (Karst.) Romell and *Omphalia sphagnicola* Berk. were

two noteworthy records. The list of Uredineae and Pyrenomycetes was considerably augmented. In particular a patch of burnt gorse yielded a number of interesting species. On the return journey a fine gathering of *Pseudombrophila tenuispora* (Cooke & Mass.) Boud. was made in a damp alder wood by the roadside.

During the week-end a short meeting was held to consider especially the locality for the 1931 Spring Foray. The suggestion which found most favour was the neighbourhood of either Horsham or East Grinstead, and Mr Pearson was asked to enquire as to possibilities in these localities. It was also suggested that it might be advantageous to avoid the Whitsun week-end, and the question of date was left to the Council.

The attached list includes all the fungi collected which it was found possible to name. For assistance in compiling it the Secretary is indebted to all the members present, and especially to Mr Petch, Mr E. W. Mason, Mr Pearson, Mr Ramsbottom, Mr Rea, Dr Alex. Smith, and Miss Page.

Complete List of Species gathered during the Foray

B. = Bawsey; *H.* = Holt House Wood; *N.* = North Wood; *R.* = Reffley; *P.* = Black Hills Plantation; *L.* = Leziate Fen; *K.* = Without exact locality.

Amanita rubescens (Pers.) Fr., *B.*, *P.*
Amanitopsis fulva (Schaeff.) W. G. Sm., *B.*, *P.*
Armillaria mellea (Vahl) Fr. (rhizomorphs), *H.*, *R.*
Tricholoma gambosum Fr., *R.*
Russula cyanoxantha (Schaeff.) Fr., *H.*, ochroleuca (Pers.) Fr., *H.*, constans (Karst.) Romell, *L.*
Mycena sanguinolenta (A. & S.) Fr., *H.*, Adonis (Bull.) Fr., *R.*, acicula (Schaeff.) Fr., *P.*
Collybia leucomyosotis Cooke & Sm., *B.*, *L.*, platyphylla (Pers.) Fr., *H.*
Marasmius oreades (Bolt.) Fr., *H.*, *L.*, esculentus (Wulf.) Karst., *B.*, *N.*, *P.*, dryophilus (Bull.) Karst., *N.*, and var. aquosus (Bull.) Rea, *L.*
Lactarius rufus (Scop.) Fr., *B.*, subdulcis (Pers.) Fr., *P.*, *L.*
Laccaria laccata (Scop.) B. & Br., *B.*, *P.*
Omphalia umbellifera (Linn.) Fr., *B.*, sphagnicola Berk., *L.*
Pluteus cervinus (Schaeff.) Fr., *N.*, *P.*, salicinus (Pers.) Fr., *R.*
Entoloma costatum Fr., *B.*
Paxillus involutus (Batsch) Fr., *B.*, *P.*
Pholiota praecox (Pers.) Fr., *H.*, *L.*, mutabilis (Schaeff.) Fr., *N.*
Inocybe lacera Fr., *B.*
Astrosporina umbrina (Bres.) Rea, *B.*
Galera tenera (Schaeff.) Fr., *R.*, hypnorum (Schrank) Fr., *B.*, *P.*
Tubaria paludosa Fr., *H.*, *N.*
Flammula sapinea Fr., *B.*
Crepidotus mollis (Schaeff.) Fr., *R.*
Psalliota campestris (Linn.) Fr., *N.*
Stropharia semiglobata (Batsch) Fr., *N.*, *L.*
Anellaria separata (Linn.) Karst., *L.*
Hypholoma fasciculare (Huds.) Fr., *B.*, *N.*, velutinum (Pers.) Fr., *R.*, appendiculatum (Bull.) Fr., *R.*
Psathyra gossypina (Bull.) Fr., *R.*
Coprinus micaceus (Bull.) Fr., *R.*, *P.*

Psathyrella disseminata (Pers.) Fr., *N.*
Boletus bovinus (Linn.) Fr., *B.*, variegatus (Swartz) Fr., *B.*, *P.*, reticulatus (Schaeff.) Boud., *P.*, duriusculus Schulz., *P.*, rugosus Fr., *P.*
Polyporus perennis (Linn.) Fr., *B.*, brumalis (Pers.) Fr., *K.*, squamosus (Huds.) Fr., *R.*, betulinus (Bull.) Fr., *B.*, *P.*, *L.*, dryadeus (Pers.) Fr., *R.*, adustus (Willd.) Fr., *H.*, fragilis Fr., *H.*, *R.*
Fomes pomaceus (Pers.) Big. & Guill., *R.*, ferruginosus (Schrad.) Mass., *R.*, annosus Fr., *P.*
Poria sanguinolenta (A. & S.) Fr., *P.*, viridans Berk., *P.*
Polystictus versicolor (Linn.) Fr., *H.*, *R.*, *P.*, abietinus (Dicks.) Fr., *B.*
Irpex obliquus (Schrad.) Fr., *P.*
Merulius himantioides Fr., *P.*
Mycoleptodon ochraceum (Pers.) Pat., *P.*, fimbriatum (Pers.) Bourd. & Galz., *P.*
Acia uda (Fr.) Bourd. & Galz., *R.*
Odontia papillosa (Fr.) Bres., *H.*
Grandinia farinacea (Pers.) Bourd. & Galz., *N.*
Hypochnus fuscus (Pers.) Fr., *N.*, fumosus Fr., *B.*, *N.*
Stereum hirsutum (Willd.) Fr., *H.*, *R.*, *P.*, purpureum Pers., *P.*
Corticium Sambuci (Pers.) Fr., *R.*, botryosum Bres., *B.*, subcoronatum v. Hoehn. & Litsch., *R.*, confine Bourd. & Galz., *H.*, *R.*, *L.*
Peniophora longispora (Pat.) v. Hoehn. & Litsch., *R.*, sanguinea (Fr.) Bres., *H.*, pubera (Fr.) Sacc., *R.*, hydnoides Cooke & Mass., *R.*, gigantea (Fr.) Mass., *N.*, incarnata (Pers.) Cooke, *L.*, cinerea (Fr.) Cooke, *H.*, *R.*
Solenia anomala (Pers.) Fr., *L.*
Auricularia auricula-Judae (Linn.) Schroet., *N.*, *R.*
Exidia Thuretiana (Lév.) Fr., *R.*
Sebacina subhyalina Pears., *R.*
Eichleriella spinulosa (B. & C.) Burt, *P.*

GASTEROMYCETES

Phallus impudicus (Linn.) Pers., *H.*, *P.*
Lycoperdon caelatum (Bull.) Fr., *K.*
Bovista plumbea Fr., *H.*

UREDINALES

Uromyces Scillarum (Grev.) Wint., *K.*, Acetosae Schroet., *L.*, Junci (Desm.) Wint., *B.*
Puccinia Calthae Link (aecidium), *L.*, Lychnidearum Link, *N.*, Malvacearum Mont., *L.*, obtegens (Link) Tul., *H.*, *L.*, Hypochaeridis Oud., *L.*, glomerata Grev., *H.*, Taraxaci Plowr., *L.*, Menthae Pers., *R.*, Caricis (Schum.) Reb. (aecidium), *N.*, *L.*, obscura Schroet., *B.*, Schoeleriana Plowr. & Magn. (aecidium), *P.*, coronata Corda (aecidium), *L.*, Phalaridis Plowr. (aecidium), *L.*, Trailii Plowr., *L.*
Phragmidium violaceum (Schultz) Wint., *R.*
Kuehneola albida Magn., *H.*
Coleosporium Senecionis (Pers.) Fr., *H.*

USTILAGINALES

Ustilago violacea (Pers.) Wint., *H.*, *L.*, longissima (Sow.) Tul., *L.*
Entyloma microsporum (Ung.) Schroet., *L.*
Urocystis Violae (Sow.) Fisch. v. Waldh., *K.*

PYRENOMYCETES

Arachniotus ruber (v. Tiegh.) Schroet., on ? rat dung, *P.*
Podosphaera leucotricha (Ell. & Ev.) Salm., *P.*
Hypomyces rosellus (A. & S.) Tul., *R.*, ochraceus Tul., *R.*

Nectria cinnabarina (Tode) Fr., on *Prunus Padus* and *Ulmus*, *R.*, Coryli Fuck., on *Ulex*, *L.*, mammoidea Phill. & Plowr., on *Ulex*, *L.*
Hypocrea fungicola Karst., on *Polyporus betulinus*, *B.*, *P.*
Epichloë typhina (Pers.) Tul., on *Dactylis*, *H.*
Philocopra collapsa (Griff.) Sacc. & D. Sacc., *K.*, curvicolla (Wint.) Sacc., on rabbit dung, *K.*
Podospora minuta (Fuck.) Wint., on rabbit dung, *K.*
Sporormia intermedia Auersw., on rabbit dung, *K.*
Leptospora spermoides (Hoffm.) Fuck., on *Betula* and other wood, *H.*
Rosellinia ligniaria (Grev.) Fuck., on *Ulex*, *L.*
Melanomma pulvispyrius (Pers.) Fuck., on *Fagus*, *K.*
Stigmatea Robertiani Fr., *L.*
Venturia inaequalis Aderh., *L.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *N.*, *L.*
Lophiotrema praemorsum (Lasch) Sacc., on *Ulex*, *L.*
Massarina alnicola (Cooke & Mass.) Berl., on *Alnus*, *K.*
Massaria popula (Fr.) Tul., on *Acer Pseudoplatanus*, *K.*
Ditopella ditopa (Fr.) Schroet., on *Alnus*, *K.*
Eutypa heteracantha Sacc., on *Sambucus*, *P.*, hydnoidea (Fr.) v. Hoehn., on *Betula*, *K.*, scabrosa (Bull.) Fuck., on *Acer campestre*, *K.*
Cryptosphaeria eunomia (Fr.) Fuck., on *Fraxinus*, *K.*
Eutypella prunastri Sacc., on *Prunus spinosa*, *P.*
Valsa cincta Fr., on *Prunus Padus*, *K.*, salicina (Pers.) Fr., on *Salix*, *K.*
Diaporthe inaequalis (Curr.) Nits., on *Ulex*, *L.*, leiphaema (Fr.) Sacc., on *Quercus*, *K.*, nucleata (Curr.) Nits., on *Ulex*, *L.*, patria Speg., on *Pyrus Aucuparia*, *H.*
Cryptospora suffusa (Fr.) Tul., on *Alnus*, *K.*
Melanconis Alni Tul. (conidial), on *Alnus*, *K.*, modonia Tul., on *Castanea*, *P.*, stilbostoma (Fr.) Tul., on *Betula*, *B.*, *P.*
Calospora platanoides (Pers.) Niessl, on *Acer Pseudoplatanus*, *K.*
Pseudovalsa lanciformis (Fr.) Ces. & de Not., on *Betula*, *K.*
Calosphaeria dryina (Curr.) Nits., on *Quercus*, *K.*
Diatrype Stigma (Hoffm.) Fr., on *Prunus*, *Salix* and *Betula*, *K.*, disciformis (Hoffm.) Fr., on *Fagus*, *K.*
Diatrypella favacea (Fr.) Nits., on *Betula*, *K.*, quercina (Pers.) Nits., on *Quercus*, *K.*, verrucaeformis (Ehrenb.) Nits., on *Alnus*, *K.*
Quaternaria quaternata (Pers.) Schroet., on *Fagus*, *K.*
Hypoxylon coccineum Bull. with Isaria umbrina Pers., on *Prunus* and *Fagus*, *R.*, fuscum (Pers.) Fr., on *Alnus*, *K.*, multiforme Fr., on *Betula* and *Pyrus Aucuparia*, *H.*, rubiginosum (Pers.) Fr., on *Fraxinus* and other wood, *K.*, semiimmersum Nits., on *Castanea*, *P.*, serpens (Pers.) Fr., on *Quercus* and *Castanea*, *P.*
Daldinia concentrica (Bolt.) Ces. & de Not., on *Ulex*, *L.*, on *Quercus*, *Betula* and *Fraxinus*, *N.*, *R.*
Xylaria Hypoxylon (Linn.) Grev., *N.*, *R.*, polymorpha (Pers.) Grev., *R.*, carpophila Fr., *P.*
Endodothella Junci (Fr.) Theiss. & Syd., *L.*
Dothidea tetraspora B. & Br., on *Ulex*, *L.*
Rhopographus filicinus (Fr.) Nits., *B.*

DISCOMYCETES

Helvella lacunosa Afz., *N.*
Ciliaria scutellata (Linn.) Quél., *H.*
Pseudombrophila tenuispora (Cooke & Mass.) Boud., *L.*
Ascobolus glaber Pers., on rabbit dung, *K.*
Taphrina Pruni (Fuck.) Tul., *H.*, Tosquinetii (West.) Magn., *H.*
Cudoniella acicularis (Bull.) Schroet., *N.*
Coryne sarcoides (Jacq.) Tul., *P.*
Corynella glabrovirens Boud., *R.*

Bulgaria inquinans (Pers.) Fr., *R.*
Orbilia xanthostigma Fr., *R.*
Chlorosplenium aeruginosum (Oeder) de Not., *R.*
Dasyscypha virginea (Batsch) Fuck., *R.*
Erinella apala (B. & Br.) Sacc., *L.*
Mollisia cinerea (Batsch) Karst., *R.*, *P.*
Rhytisma acerinum (Pers.) Fr., *P.*

PHYCOMYCETES

Synchytrium Taraxaci de By. & Wor., *L.*
Cystopus candidus (Pers.) de By., *P.*
Plasmopara nivea (Unger) Schroet., *H.*, *L.*, densa (Rabenh.) Schroet., *L.*
Peronospora alsinearum Caspary, *R.*, *L.*, trifoliorum de By., *L.*, arborescens (Berk.) de By., *L.*, grisea Unger, *R.*, parasitica (Pers.) Tul., *L.*, Polygoni Thuem., *P.*
Mucor Mucedo (Linn.) Bref., *K.*, racemosus Fres., on rabbit dung, *K.*
Rhizopus stolonifer (Ehrenb.) Lind, *K.*

PROTOMYCETACEAE

Protomyces macrosporus Unger, *H.*, pachydermus Thuem., *L.*

DEUTEROMYCETES

Phyllosticta hedericola Dur. & Mont., *R.*
Oidium alphitoides Griff. & Maubl., *P.*
Gliocladium penicillioides Corda, on *Physarum nutans*, *R.*
Acremonium album Preuss, on *Comatricha*, *B.*
Ovularia obliqua (Cooke) Oud., *B.*, *L.*
Botrytis cinerea Pers., *H.*, *N.*
Ramularia calcea (Desm.) Ces., *R.*, Primulae Thuem., *N.*
Rhinotrichum Thwaitesii B. & Br., *R.*, niveum Cooke & Mass., *P.*
Rhynchosporium Secalis (Oud.) Davis, *N.*
Helminthosporium gramineum Rabenh., *N.*, *L.*
Isaria farinosa (Dicks.) Fr., *R.*
Dendrodochium citrinum Grove, *P.*

MYCETOZOA

By H. J. HOWARD

The weather previous to the foray had been wet and this was succeeded by fine, warm weather; the result was that some of the gatherings found were not quite of a normal type. The district proved a very good one and a large area was covered somewhat hurriedly; the Black Hills Wood proved an excellent hunting ground. A large number of gatherings were made, and the number of species for the time of the year showed a marked contrast to those found under exceedingly dry conditions at the Petersfield Foray the previous year.

The most interesting gatherings made were: *Physarum psittacinum* Ditm., the glossy purplish sporangia faintly mottled with red being almost sessile, and only in one or two sporangia was the orange-red translucent stalk visible; the spores were very variable in size being from 8 to 12 μ. *Stemonitis fusca* Roth; in addition to gatherings of the

normal type, one was a very short form with sporangia 2 to 2.5 mm. in height and with the surface net imperfectly developed; the spores showed considerable difference in markings, for instead of being closely reticulate and spinulose, they were marked with scattered ridges sometimes combined into an imperfect reticulation. Miss Lister kindly examined this specimen and concluded that it was an imperfect, dry weather form.

R.W. = Reffley Wood; *B.H.* = Black Hills Wood; *L.F.* = Leziate Fen; *R.C.* = Roydon Common; *G.W.* = Grimston Warren; *M.* = Middleton; *B.* = Bawsey; *N.W.* = North Wood.

Ceratiomyxa fruticulosa (Muell.) Macbr., *R.W.*, *M.*, *B.*
Physarum viride Pers., *B.H.*, nutans Pers., *B.H.* (several gatherings), *N.W.*, psittacinum Ditm., *B.H.*
Fuligo septica Gmel., *B.H.*, *M.*, *N.W.*, *B.*
Didymium difforme Duby, *L.F.*
Mucilago spongiosa Morgan, *R.C.*
Stemonitis fusca Roth., *R.W.*, *B.H.* (type and dwarf forms).
Comatricha nigra Schroet., *R.W.*, *B.H.*, *G.W.*, *M.*, *N.W.*
Enerthenema papillatum Rost., *B.H.*
Cribraria vulgaris Schrad., *B.H.*, *G.W.*
Dictydium cancellatum Macbr., *B.H.*
Reticularia Lycoperdon Bull., *R.C.*, *N.W.*, *B.*
Lycogala epidendrum Fr., *R.W.*, *B.H.*, *M.*
Trichia persimilis Karst., *B.H.*, *M.*
Arcyria ferruginea Saut., *N.W.*, cinerea Pers., *M.*, denudata (L.) Wettst., *R.W.*, *B.H.*, incarnata Pers., *B.H.*, nutans Grev., *B.H.*

It might be added that during the foray, Mr Petch handed me the specimen of *Lamproderma echinulatum* Rost. found by him on an old log at Middleton during the first week in March of this year; this constitutes a new record for Norfolk.

THE WHITBY FORAY

September 15th–20th, 1930

By E. M. WAKEFIELD

The thirty-fourth Autumn Foray and Annual General Meeting was held at Whitby, Yorkshire, in conjunction with the Mycological Section of the Yorkshire Naturalists' Union, during the week September 15th–20th. Headquarters were at the Crown Hotel, which was completely filled by mycologists, with an overflow into rooms outside. In addition to our own members and members of the Y.N.U., we were glad to welcome a number of foreign mycologists who had been attending the International Botanical Congress and had availed themselves of this opportunity to join the Foray. Dr and Mrs Shear, Professor and Mrs G. P. Clinton, Dr and Mrs C. W. Dodge, Miss A. E. Jenkins and Dr Neil Stevens provided a splendid representation of the United States of America, and Mr M. A. Donk attended from Holland. It was therefore especially pleasing that the season was good, and that the district came up to expectations in providing plenty of interesting fungi for examination and comparisons.

The main party assembled in the evening of Monday, September 15th, but early arrivals had already been busy in Mulgrave Woods and had set out a fine lot of fungi on the tables, including such good things as *Psalliota villatica*, *Russula luteotacta*, *Pleurotus geogenius*, and *Clavaria amethystina*.

The first day's excursion was also to Mulgrave Woods, where the larger fungi were found to be very abundant. In particular the large number of Clavarias and Hygrophori recorded is worthy of note. One *Clavaria*, a branched grey species allied to *C. corniculata*, gave rise to considerable discussion. It does not seem to fit any described species exactly, and Mr Rea has decided to name it as new. Some very large forms of *C. cinerea* were found. Among the many other good finds may be mentioned *Lepiota puellaris*, *Inocybe corydalina*, *I. Godeyi*, *I. incarnata*, *Psalliota amethystina*, *Leptopodia elastica*, *Otidea concinna*, and *Geaster rufescens*.

On the Wednesday, Arncliffe Woods, Glaisdale, were worked. It was interesting to see here some of the damage which had been done by the floods of the summer of 1930. The woods, which clothed the steep slopes of the river bank, provided some interesting fungi. Early in the day *Mycena crocata* was collected. Mr Tomkins secured *Nolanea strigosissima* Rea, the second collection of this species. A number of microfungi, especially Rusts, were added to the list from Arncliffe.

Thursday, very cold after a night of wind and rain, was spent in woods at Kingthorpe, near Pickering. Here *Hydnum auriscalpium* was added to the list. The party divided, and one set worked a bit of pasture and a large beech wood on the side of the road opposite to where the main party had entered. The beech wood was remarkable for the great abundance of *Marasmius cohaerens* and especially *M. globularis*. The latter occurred in dense clusters, in groups sometimes covering a square yard. *Inocybe incarnata* was again found, and *Mycena pelianthina* was fairly common in the same wood. *Cordyceps militaris*, and especially the conidial stage, *Isaria farinosa*, was abundant, as also at Arncliffe on the previous day. *Lepiota Bucknallii*, *Laccaria tortilis*, *Hygrophorus nigrescens*, *Entoloma Bloxami*, and *Polystictus Wynnei* were other good finds of the day.

The last day of the Foray was very wet, rain falling unceasingly from soon after the start until evening. This day was spent in the Goathland district, chiefly about Beck Hole. In spite of the weather, which compelled all to return early to seek hot baths and dry clothes, some interesting records were made. The first wood entered was largely coniferous, and provided the usual species found in such habitats. Mr Pearson reported later *Omphalia atropuncta*, *Leptonia solstitialis* and *L. sericella*, and *Inocybe posterula* Britz. On the homeward journey numerous patches of *Corticium fuciforme*, in the sterile condition, were noticed on the moor. This species was evidently favoured by the wet autumn, as it appears to have been unusually plentiful everywhere, and has caused much concern to owners of lawns and bowling greens.

The Annual General Meeting was held on the Tuesday evening, when the Officers and Council for the ensuing year were elected. Mr A. A. Pearson, F.L.S., was unanimously elected as President for 1931. Sir Rowland H. Biffen and Mr T. Petch are Vice-Presidents. The Treasurer and Secretaries remain as before, but owing to Mr Rea's resignation of his post of co-editor, two assistant editors, Dr B. Barnes and Dr H. Wormald, have been appointed to help Mr Ramsbottom. The number of elected members of Council was increased, four new members, Mr G. N. Bunyard, Col. C. T. Green, Mr R. W. Marsh, and Mr R. G. Tomkins, being elected to replace the two retiring members.

The status and future of the Plant Pathology Subcommittee were discussed. It was decided that the name should properly be Committee for Plant Pathology. Five new members were elected, namely, Mr Beaumont, Mr Harris, Mr Marsh, Mr Moore and Mr Tomkins, and the Committee was instructed to bring forward a scheme as to its constitution at the next Annual General Meeting.

A warm invitation to hold the 1931 Autumn Foray in Belfast was received from Mr Muskett, and was accepted.

The President, Sir Rowland H. Biffen, F.R.S., delivered his Presidential Address on the Wednesday evening. It was entitled "The Cereal Rusts and their Control," and gave rise to an interesting discussion.

On Thursday, Mr Rea discussed the finds of the week, and on Friday evening, Mr A. E. Peck entertained both members and the public with a racy lantern lecture.

The week's meetings ended with hearty votes of thanks to landowners and to others who had helped to make the Foray a success, and in particular to Mr A. E. Peck, Secretary of the Mycological Committee of the Y.N.U., who had made all the local arrangements.

The attached list of species collected shows well the influence of the presence of specialists, who made themselves responsible for their own groups. The interesting list of Pyrenomycetes, with their hosts, is mainly due to the work of Mr E. W. Mason and Dr C. L. Shear. Mr Mason notes that the most noteworthy finds were *Bombardia fasciculata*, which is distinctly uncommon in the south of England, but, judging from Massee and Crossland's list, is more common in Yorkshire, and *Eutypella Sorbi* on Mountain Ash, which was growing on trees close to Elm with abundant *Eutypella stellulata*. It is possible that *E. Sorbi* is only *E. stellulata* growing on Mountain Ash. The records of *Berlesiella nigerrima*, *Chaetosphaeria phaeostroma*, *Diaporthe pulla* and *Xylaria longipes* were made by Dr Shear.

Mr Petch was responsible for all the entomogenous and coprophilous fungi listed, as well as for a number of other microfungi. Dr Alex. Smith and Mr Ramsbottom took care of the Rust fungi and Phycomycetes, and the list of Mycetozoa was sent in by Miss Cayley and Dr W. T. Elliott. Exact localities for the Mycetozoa are not given.

The Secretary is also indebted to Mr Pearson, Mr Ramsbottom, and Mr Rea for records of Basidiomycetes and Discomycetes, and in general to all members present.

Complete List of Species gathered during the Foray

M. = Mulgrave Woods, Sandsend; *A.* = Arncliffe Woods, Glaisdale; *K.* = Kingthorpe Woods, near Pickering; *G.* = Goathland; *R.* = ground near Reservoir, between Guisborough and Whitby.

HYMENOMYCETES

Amanita phalloides (Vaill.) Fr., *M.*, and var. verna (Bull.) Fr., *A.*, porphyria (A. & S.) Fr., *G.*, mappa (Batsch) Fr., *A.*, muscaria (Linn.) Fr., *G.*, spissa Fr., *A.*, *G.*, rubescens (Pers.) Fr., *M.*, *A.*, *G.*

Amanitopsis vaginata (Bull.) Roze, *G.*, fulva (Schaeff.) W. G. Sm., *A.*, *G.*

Lepiota rhacodes (Vitt.) Fr., *M.*, *K.*, puellaris (Fr.) Rea, *M.*, acutesquamosa (Weinm.) Fr., *K.*, Friesii (Lasch) Fr., *A.*, *K.*, cristata (A. & S.) Fr., *M.*, *A.*, *K.*, amianthina (Scop.) Fr., *A.*, *G.*, carcharias (Pers.) Fr., *A.*, sistrata Fr., *K.*, Bucknallii B. & Br., *K.*

Armillaria mellea (Vahl) Fr., rhizomorphs only, *M.*, *A.*

Tricholoma resplendens Fr., *A.*, fulvum (DC.) Fr., *M.*, albobrunneum (Pers.) Fr., *M.*, *A.*, *K.*, rutilans (Schaeff.) Fr., *M.*, *A.*, *K.*, *G.*, imbricatum Fr., *M.*, terreum (Schaeff.) Fr., *M.*, argyraceum (Bull.) Fr., *M.*, *A.*, murinaceum (Bull.) Fr., *M.*, *K.*, saponaceum Fr., *M.*, *A.*, *K.*, *G.*, sulphureum (Bull.) Fr., *M.*, inamoenum Fr., *K.*, carneum (Bull.) Fr., *R.*, album (Schaeff.) Fr., *K.*, acerbum (Bull.) Fr., *M.*, personatum Fr., *G.*, melaleucum (Pers.) Fr., *M.*, *K.*, sordidum (Schum.) Fr., *M.*

Clitocybe clavipes (Pers.) Fr., *G.*, aurantiaca (Wulf.) Studer, *G.*, odora (Bull.) Fr., *M.*, cerussata Fr., *A.*, candicans (Pers.) Fr., *K.*, dealbata (Sow.) Fr., *M.*, tumulosa (Kalchbr.) Fr., *M.*, *K.*, infundibuliformis (Schaeff.) Fr., *M.*, *A.*, *G.*, incilis Fr., *K.*, gilva Fr., *G.*, inversa (Scop.) Fr., *K.*, vibecina Fr., *K.*, suaveolens (Schum.) Fr., *M.*, *K.*, ditopus Fr., *M.*, *K.*

Laccaria laccata (Scop.) B. & Br., *M.*, *A.*, *G.*, and var. amethystina (Vaill.) B. & Br., *M.*, *A.*, *G.*, tortilis (Bolt.) Boud., *K.*

Collybia radicata (Relh.) Berk., *A.*, platyphylla (Pers.) Fr., *A.*, maculata (A. & S.) Fr., *A.*, *R.*, butyracea (Bull.) Fr., *M.*, *K.*, *G.*, velutipes (Curt.) Fr., *M.*, rancida Fr., *K.*

Mycena pelianthina Fr., *M.*, *K.*, avenacea (Fr.) Schroet., *M.*, rubromarginata Fr., *M.*, pura (Pers.) Fr., *M.*, *A.*, *K.*, *G.*, Adonis (Bull.) Fr., *M.*, *K.*, lactea (Pers.) Fr., *M.*, rugosa Fr., *A.*, *K.*, galericulata (Scop.) Fr., *M.*, *A.*, polygramma (Bull.) Fr., *K.*, inclinata Fr., *M.*, *A.*, *G.*, ammoniaca Fr., *M.*, *G.*, metata Fr., *M.*, Iris Berk., *G.*, vitilis Fr., *M.*, haematopus (Pers.) Fr., *M.*, sanguinolenta (A. & S.) Fr., *M.*, *A.*, *K.*, *G.*, crocata (Schrad.) Fr., *A.*, galopus (Pers.) Fr., *M.*, *A.*, *K.*, *G.*, var. alba Fl. Dan., *K.*, *G.*, var. nigra Fl. Dan., *K.*, *G.*, epipterygia (Scop.) Fr., *A.*

Omphalia atropuncta (Pers.) Quél., *G.*, fibula (Bull.) Fr., *M.*, *A.*, *G.*

Pleurotus ostreatus (Jacq.) Fr., *A.*, geogenius (DC.) Fr., *M.*, septicus Fr., *A.*, algidus Fr., *M.*

Hygrophorus eburneus (Bull.) Fr., *M.*, *K.*, leporinus Fr., *M.*, *A.*, pratensis (Pers.) Fr., A., *G.*, and var. cinereus Fr., *G.*, virgineus (Wulf.) Fr., *M.*, *A.*, *K.*, *G.*, and var. roseipes Mass., *K.*, russocoriaceus Berk. & Miller, *G.*, laetus (Pers.) Fr., *M.*, *A.*, ceraceus (Wulf.) Fr., *M.*, coccineus (Schaeff.) Fr., *M.*, *A.*, *G.*, miniatus Fr., *G.*, Reai Maire, *K.*, puniceus Fr., *M.*, *A.*, nigrescens Quél., *M.*, *K.*, *G.*, obrusseus Fr., *M.*, intermedius Pass., *A.*, conicus (Scop.) Fr., *M.*, *K.*, *G.*, calyptraeformis Berk., *M.*, psittacinus (Schaeff.) Fr., *M.*, *A.*, *G.*, unguinosus Fr., *A.*, *K.*

Lactarius torminosus (Schaeff.) Fr., *G.*, turpis (Weinm.) Fr., *A.*, *G.*, zonarius (Bull.) Fr., *M.*, blennius Fr., *M.*, *A.*, *K.*, uvidus Fr., *K.*, *G.*, pyrogalus (Bull.) Fr., *M.*, *A.*, chrysorrheus Fr., *A.*, *G.*, piperatus (Scop.) Fr., *A.*, *G.*, vellereus Fr., *M.*, *A.*, *G.*, deliciosus (Linn.) Fr., *M.*, *R.*, pallidus (Pers.) Fr., *M.*, *K.*, quietus Fr., *M.*, *A.*, *K.*, *G.*, aurantiacus (Fl. Dan.) Fr., *M.*, vietus Fr., *A.*, *G.*, rufus (Scop.) Fr., *G.*, glyciosmus Fr., *M.*, *K.*, fuliginosus Fr., *M.*, picinus Fr., *A.*, volemus Fr., *A.*, *K.*, serifluus (DC.) Fr., *M.*, *A.*, *G.*, mitissimus Fr., *M.*, *A.*, subdulcis (Pers.) Fr., *M.*, *A.*, *K.*, *G.*

Russula nigricans (Bull.) Fr., *M.*, *A.*, *K.*, *G.*, adusta (Pers.) Fr., *K.*, *G.*, lepida Fr., *A.*, *K.*, *G.*, cyanoxantha (Schaeff.) Fr., *M.*, *A.*, *G.*, furcata (Pers.) Fr., *M.*, foetens (Pers.) Fr., *M.*, *A.*, *G.*, ochroleuca (Pers.) Fr., *M.*, *A.*, *K.*, *G.*, and var. granulosa (Cooke) Rea, *K.*, fellea Fr., *M.*, *A.*, *K.*, drimeia Cooke, *M.*, *K.*, and var. Queletii (Fr.) Bat., *M.*, fragilis (Pers.) Fr., *M.*, *A.*, *K.*, *G.*, cmetica (Schaeff.) Fr., *M.*, *A.*, *K.*, *G.*, luteotacta Rea, *M.*, atropurpurea (Krombh.) Maire, *M.*, *A.*, and var. depallens (Cooke) Maire, *K.*, *G.*, aurora Bres., *A.*, vesca Fr., *A.*, mustelina Fr., *G.*

Cantharellus cibarius Fr., *M.*, *A.*, *K.*, *G.*, infundibuliformis (Scop.) Fr., *A.*, *K.*, *G.*

Nyctalis parasitica (Bull.) Fr., *M.*, *A.*, *K.*, asterophora Fr., *K.*

Marasmius peronatus (Bolt.) Fr., *M.*, *A.*, *K.*, *G.*, globularis Fr., *K.*, erythropus (Pers.) Fr., *A.*, *K.*, *G.*, undatus (Berk.) Quél., *M.*, *A.*, hariolorum (DC.) Quél., *M.*, *A.*, *K.*, *G.*, dryophilus (Bull.) Karst., *A.*, *K.*, and var. aquosus (Bull.) Rea, *M.*, ramealis (Bull.) Fr., *K.*, *G.*, cohaerens (A. & S.) Cooke, *K.*

Androsaceus rotula (Scop.) Pat., *M.*, *K.*, androsaceus (Linn.) Pat., *A.*
Panus stipticus (Bull.) Fr., *K.*
Plutcus cervinus (Schaeff.) Fr., *M.*, salicinus (Pers.) Fr., *K.*, nanus (Pers.) Fr., *M.*, and var. lutescens Fr., *K.*
Entoloma lividum (Bull.) Fr., *K.*, Bloxami Berk., *K.*, jubatum Fr., *M.*, *G.*, sericeum (Bull.) Fr., *G.*, nidorosum Fr., *M.*, *A.*, *K.*, *G.*
Nolanea pascua (Pers.) Fr., *M.*, *A.*, *K.*, *G.*, cetrata Schroet., *A.*, *R.*, *G.*, strigosissima Rea, *A.*, papillata Bres., *K.*
Leptonia lampropus Fr., *M.*, *A.*, *K.*, *G.*, solstitialis Fr., *G.*, incana Fr., *K.*, *G.*, sericella (Fr.) Quél., *G.*
Clitopilus prunulus (Scop.) Fr., *M.*, *A.*, *K.*
Paxillus involutus (Batsch) Fr., *M.*, *A.*, *G.*, panuoides Fr., *M.*, *K.*
Pholiota erebia Fr., *M.*, radicosa (Bull.) Fr., *K.*, *G.*, heteroclita Fr., *M.*, squarrosa (Müll.) Fr., *M.*, *K.*, spectabilis Fr., *K.*, flammans Fr., *K.*, mutabilis (Schaeff.) Fr., *K.*, *G.*, marginata (Batsch) Fr., *A.*
Inocybe tomentosa (Jungh.) Quél., *K.*, corydalina Quél., *M.*, geophylla (Sow.) Fr., *M.*, *A.*, and var. lilacina Fr., *A.*, *K.*, Godeyi Gill., *M.*, obscura (Pers.) Fr., *K.*, hystrix Fr., *A.*, *G.*, incarnata Bres., *M.*, *K.*, cincinnata Fr., *M.*, posterula Britz., *G.*
Astrosporina duriuscula Rea, *M.*
Hebeloma fastibile Fr., *M.*, *K.*, mesophaeum Fr., *K.*, crustuliniforme (Bull.) Fr., *M.*, elatum (Batsch) Fr., *M.*
Galera tenera (Schaeff.) Fr., *A.*, rubiginosa (Pers.) Fr., *A.*, hypnorum (Schrank) Fr., *M.*, *A.*, *K.*, *G.*
Naucoria Cucumis (Pers.) Fr., *M.*, melinoides Fr., *G.*, badipes Fr., *A.*
Tubaria furfuracea (Pers.) W. G. Sm., *G.*, inquilina (Fr.) W. G. Sm., *M.*
Flammula gummosa (Lasch) Fr., *M.*, *A.*, sapinea Fr., *M.*, *A.*, *K.*, ochrochlora Fr., *M.*
Cortinarius (Phlegmacium) triumphans Fr., *A.*, varius (Schaeff.) Fr., *M.*, cyanopus (Secr.) Fr., *A.*, orichalceus (Batsch) Fr., *M.*, (Myxacium) mucosus (Bull.), Fr., *K.*, elatior Fr., *M.*, *A.*, *G.*, delibutus Fr., *G.*, (Inoloma) pholideus Fr., *A.*, (Dermocybe) tabularis (Bull.) Fr., *M.*, *A.*, caninus Fr., *G.*, anomalus Fr., *A.*, lepidopus Cooke, *A.*, phoeniceus (Bull.) Maire, *M.*, cinnabarinus Fr., *M.*, *G.*, sanguineus (Wulf.) Fr. *A.*, cinnamomeus (Linn.) Fr., *A.*, *G.*, (Telamonia) bulbosus (Sow.) Fr., *M.*, torvus Fr., *K.*, hinnuleus (Sow.) Fr., *M.*, gentilis Fr., *M.*, hemitrichus Fr., *M.*, stemmatus Fr., *M.*, rigidus (Scop.) Fr., *A.*, paleaceus (Weinm.) Fr., *M.*, *A.*, (Hydrocybe) duracinus Fr., *G.*, saturninus Fr., *M.*, *A.*, castaneus (Bull.) Fr., *M.*, *G.*, obtusus Fr., *A.*, *G.*, acutus (Pers.) Fr., *G.*
Crepidotus mollis (Schaeff.) Fr., *M.*, applanatus (Pers.) Fr., *A.*
Psalliota xanthoderma Genev., *K.*, flavescens Gill., *K.*, arvensis (Schaeff.) Fr., *M.*, campestris (Linn.) Fr., *K.*, villatica (Brond.) Magn., *M.*, *G.*, sylvatica (Schaeff.) Fr., *K.*, haemorrhoidaria Kalchbr., *M.*, amethystina Quél., *M.*
Stropharia aeruginosa (Curt.) Fr., *M.*, *A.*, *K.*, semiglobata (Batsch) Fr., *M.*, *G.*, hypsipus Fr., *K.*
Hypholoma fasciculare (Huds.) Fr., *M.*, *A.*, *K.*, *G.*, epixanthum Fr., *G.*, radicosum Lange, *K.*, dispersum Fr., *M.*, velutinum (Pers.) Fr., *M.*, *A.*, appendiculatum (Bull.) Fr., *M.*, Candolleanum Fr., *A.*, pilulaeforme (Bull.) Fr., *M.*, hydrophilum (Bull.) Fr., *M.*
Psilocybe sarcocephala Fr., *K.*, uda (Pers.) Fr., *G.*, semilanceata Fr., *A.*, *G.*, physaloides (Bull.) Fr., *G.*, foenisecii (Pers.) Fr., *A.*
Psathyra conopilea Fr., *M.*, *K.*, corrugis (Pers.) Fr., *M.*, gossypina (Bull.) Fr., *A.*, fibrillosa (Pers.) Fr., *G.*
Psathyrella gracilis Fr., *M.*, disseminata (Pers.) Fr., *M.*, *A.*, atomata Fr., *M.*
Panaeolus campanulatus (Linn.) Fr., *A.*
Coprinus comatus (Fl. Dan.) Fr., *M.*, atramentarius (Bull.) Fr., *M.*, *A.*, picaceus (Bull.) Fr., *K.*, micaceus (Bull.) Fr., *M.*, *A.*, *K.*, lagopus Fr., *K.*, plicatilis (Curt.) Fr., *M.*
Gomphidius viscidus (Linn.) Fr., *K.*

Boletus castaneus (Bull.) Fr., *A.*, felleus (Bull.) Fr., *A.*, *G.*, elegans (Schum.) Fr., *M.*, *A.*, *K.*, *G.*, granulatus (Linn.) Fr., *A.*, badius Fr., *A.*, chrysenteron (Bull.) Fr., *M.*, *A.*, *R.*, subtomentosus (Linn.) Fr., *M.*, *A.*, erythropus (Pers.) Quél., *A.*, duriusculus Schulz., *G.*, versipellis Fr., *G.*, scaber (Bull.) Fr., *M.*, *G.*

Polyporus nummularius (Bull.) Quél., *M.*, *K.*, varius Fr., *M.*, *K.*, *R.*, squamosus (Huds.) Fr., *M.*, *K.*, giganteus (Pers.) Fr., *M.*, betulinus (Bull.) Fr., *M.*, *A.*, *G.*, dryadeus (Pers.) Fr., *M.*, hispidus (Bull.) Fr., *M.*, radiatus (Sow.) Fr., *M.*, *K.*, *G.*, fumosus (Pers.) Fr., *M.*, Wynnei B. & Br., *K.*, caesius (Schrad.) Fr., *K.*

Fomes pomaceus (Pers.) Big. & Guill., *M.*, ferruginosus (Schrad.) Mass., *K.*, annosus Fr., *M.*, *A.*, *K.*

Ganoderma applanatum (Fr.) Pat., *M.*

Polystictus versicolor (Linn.) Fr., *M.*, *A.*, *G.*

Irpex obliquus (Schrad.) Fr., *A.*, *K.*

Trametes mollis (Sommerf.) Fr., *M.*

Daedalea biennis (Bull.) Quél., *M.*, quercina (Linn.) Fr., *M.*, *A.*, *G.*

Merulius tremellosus (Schrad.) Fr., *K.*, Corium (Pers.) Fr., *M.*

Phlebia merismoides Fr., *M.*

Coniophora puteana (Schum.) Karst., *M.*

Fistulina hepatica (Huds.) Fr., *M.*, *A.*, *K.*

Hydnum repandum (Linn.) Fr., *M.*, *A.*, *K.*, *G.*, and var. rufescens (Pers.) Fr., *M.*, *A.*, *K.*, *G.*, auriscalpium (Linn.) Fr., *K.*

Mycoleptodon fimbriatum (Pers.) Bourd. & Galz., *M.*, *K.*

Radulum quercinum Fr., *K.*, *G.*

Acia uda (Fr.) Bourd. & Galz., *M.*

Grandinia farinacea (Pers.) Bourd. & Galz., *M.*, *G.*, helvetica (Pers.) Fr., *K.*

Craterellus cornucopioides (Linn.) Fr., *M.*, *A.*, *G.*

Thelephora anthocephala (Bull.) Fr., *A.*, terrestris Ehrh., *G.*

Hypochnus ferrugineus (Pers.) Fr., *K.*, umbrinus (Fr.) Quél., *K.*, fuscus (Pers.) Fr., *K.*, *G.*, fumosus Fr., *K.*

Stereum spadiceum Fr., *A.*, sanguinolentum (A. & S.) Fr., *K.*, hirsutum (Willd.) Fr., *M.*, *A.*, *K.*, *G.*, rugosum (Pers.) Fr., *A.*, *K.*, purpureum Pers., *A.*

Hymenochaete rubiginosa (Dicks.) Lév., *K.*

Corticium fuciforme (Berk.) Wakef., *G.*, Sambuci Pers., *K.*, botryosum Bres., *A.*, *G.*, confluens Fr., *A.*, confine Bourd. & Galz., *A.*, *K.*, *G.*, porosum B. & C., *K.*, lactescens Berk., *M.*, fastidiosum (Fr.) Bourd. & Galz., *K.*

Peniophora byssoidea (Pers.) v. Hoehn. & Litsch., *M.*, *K.*, sanguinea (Fr.) Bres., mycelium only, *A.*, hydnoides Cooke & Mass., *K.*, cinerea (Fr.) Cooke, *K.*, velutina (DC.) Cooke, *M.*

Cyphella capula (Holmsk.) Fr., *K.*, and var. flavescens Pat., *K.*

Solenia anomala (Pers.) Fr., *M.*

Clavaria cristata (Holmsk.) Fr., *M.*, *A.*, *K.*, cinerea (Bull.) Fr., *M.*, *A.*, *K.*, amethystina (Batt.) Fr., *M.*, rugosa (Bull.) Fr., *M.*, *A.*, *K.*, Kunzei Fr., *M.*, corniculata (Schaeff.) Fr., *M.*, *A.*, *K.*, flava (Schaeff.) Fr., *M.*, abietina (Pers.) Fr., *M.*, stricta (Pers.) Fr., *M.*, *A.*, rosea (Dalman) Fr., *M.*, *A.*, fusiformis (Sow.) Fr., *M.*, *A.*, *G.*, inaequalis (Müll.) Fr., *M.*, *A.*, *G.*, persimilis Cotton, *M.*, straminea Cotton, *M.*, acuta (Sow.) Fr., *A.*, vermicularis Fr., *M.*, fumosa (Pers.) Fr., *M.*, *G.*, pistillaris (Linn.) Fr., *M.*

Exobasidium Vaccinii (Fuck.) Woron., on *Vaccinium Myrtillus*, *G.*

Auricularia auricula-Judae (Linn.) Schroet., *M.*

Tremella foliacea (Pers.) Fr., *M.*, *K.*, *G.*, lutescens Pers., *A.*, *K.*, mesenterica (Retz.) Fr., *M.*, *K.*

Exidia glandulosa (Bull.) Fr., *G.*, nucleata (Schw.) Rea, *K.*

Dacryomyces deliquescens (Bull.) Duby, *M.*, *K.*

Calocera viscosa (Pers.) Fr., *M.*, *A.*, *G.*, cornea (Batsch) Fr., *M.*, *A.*

GASTEROMYCETES

Cynophallus caninus (Huds.) Fr., *A.*, *K.*

Phallus impudicus (Linn.) Pers., *A.*, *G.*

Lycoperdon perlatum Pers., *M.*, depressum Bon., *M.*, *K.*, umbrinum Pers., *A.*, *K.*, pyriforme (Schaeff.) Pers., *M.*, *A.*, *K.*, *G.*
Bovista plumbea Fr., *A.*
Geaster fimbriatus Fr., *K.*, rufescens Pers., *M.*
Crucibulum vulgare Tul., *M.*
Scleroderma aurantium Pers., *M.*, *A.*, *G.*, verrucosum (Vaill.) Pers., *M.*, *K.*
Sphaerobolus stellatus (Tode) Pers., *M.*

UREDINALES

Uromyces flectens Lagerh., *M.*, Valerianae (Schum.) Fuck., *A.*
Puccinia Violae (Schum.) DC., *A.*, Lychnidearum Link., *M.*, *A.*, *K.*, Malvacearum Mont., *M.*, Epilobii DC., *A.*, Circaeae Pers., *M.*, *K.*, Saniculae Grev., *M.*, *A.*, *K.*, obtegens (Link) Tul., *A.*, Hieracii (Schum.) Mart., *A.*, Lampsanae (Schultz) Fuck., *A.*, Primulae (DC.) Duby, *A.*, Veronicae Schroet., *K.*, Glechomatis DC., *M.*, Menthae Pers., *M.*, obscura Schroet., *A.*, *K.*, Caricis (Schum.) Rebent., *A.*, holcina Erikss., *A.*, Baryi (B. & Br.) Wint., *K.*, sessilis Schneid., *K.*
Triphragmium Ulmariae (Schum.) Link, *M.*, *K.*
Phragmidium violaceum (Schultz) Wint., *M.*, *A.*, *K.*, *G.*
Coleosporium Senecionis (Pers.) Fr., *A.*, Tussilaginis (Pers.) Kleb., *M.*, *A.*
Pucciniastrum Circaeae (Schum.) Schroet., *M.*, *A.*
Milesina Blechni Syd., *K.*
Melampsoridium betulinum (Pers.) Kleb., *M.*, *A.*

USTILAGINALES

Ustilago violacea (Pers.) Wint., *A.*
Entyloma microsporum (Ung.) Schroet., *K.*

PLECTASCALES

Arachniotus candidus (Eidam) Schroet., on broken lepidopterous pupa, *A.*
Ctenomyces serratus Eidam, *M.*
Onygena corvina A. & S., on dog's dung, *M.*

PYRENOMYCETES

Sphaerotheca pannosa (Wallr.) Lév., *M.*
Erysiphe Polygoni DC., on *Anthriscus*, *A.*, on *Heracleum*, *M.*, *A.*, *K.*, *G.*, Cichoriacearum DC., on *Arctium.*, *M.*, *K.*, *G.*, graminis DC., *K.*
Microsphaera Grossulariae (Wallr.) Lév., *K.*
Uncinula Aceris (DC.) Sacc., *M.*
Nectria Aquifolii (Fr.) Berk., on *Ilex*, *G.*, sinopica Fr., on *Hedera*, *K.*, cinnabarina (Tode) Fr., on *Aesculus*, *M.*, *K.*, coccinea (Pers.) Fr., on *Fagus*, *M.*, episphaeria (Tode) Fr., on *Ulmus*, *M.*, *K.*, sanguinea (Sibth.) Fr., *M.*, on *Fraxinus*, *K.*
Hypomyces aurantius (Pers.) Tul., *M.*
Hypocrea rufa (Pers.) Fr., *A.*, gelatinosa (Tode) Fr., *M.*
Claviceps purpurea (Fr.) Tul., on *Holcus mollis*, *A.*
Cordyceps militaris (Linn.) Fr., *A.*, *K.*, ophioglossoides (Ehrh.) Link, *A.*
Trichosphaeria minima (Fuck.) Wint., on *Ulmus*, *K.*
Lasiosphaeria hispida (Tode) Fuck., on *Ulmus*, *M.*
Leptospora ovina (Pers.) Fuck., on *Fraxinus*, *K.*
Rosellinia aquila (Fr.) de Not., on *Ulmus*, *M.*, *K.*, on *Fraxinus*, *K.*, mammaeformis (Pers.) Sacc., *M.*
Bombardia fasciculata Fr., on *Fraxinus*, *K.*
Bertia moriformis (Tode) de Not., on *Fagus*, *M.*, on *Ulmus* and *Fraxinus*, *K.*
Chaetosphaeria phaeostroma (Mont.) Fuck., on *Acer*, *A.*
Melanomma pulvis-pyrius (Pers.) Fuck., on *Acer* and *Ulmus*, *M.*, *A.*, on *Ilex*, *G.*, and on *Fraxinus*, *K.*, *G.*

Zignöella pulviscula (Curr.) Sacc., on *Fraxinus* and *Fagus*, *K.*
Berlesiella nigerrima (Blox.) Sacc., on *Eutypa* sp., *A.*
Stigmatea Robertiani Fr., *M.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *K.*
Diaporthe pulla Nits. (no spores), on *Hedera*, *K.*, controversa (Desm.) Fuck., on *Fraxinus*, *K.*, scobina Nits., on *Fraxinus*, *K.*, leiphaemia (Fr.) Sacc., on *Quercus*, *A.*, Niesslii Sacc., on *Acer*, *K.*
Eutypa Acharii Tul., on *Acer*, *G.*, flavovirescens (Hoffm.) Sacc., on *Crataegus* and *Ulmus*, *M.*, lata (Pers.) Tul., on *Aesculus*, *M.*
Cryptosphaeria eunomia (Fr.) Fuck., on *Fraxinus*, *K.*
Eutypella stellulata (Fr.) Sacc., on *Ulmus*, *M.*, *K.*, Sorbi (Schum.) Sacc., on *Pyrus Aucuparia*, *K.*
Valsa ambiens (Pers.) Fr., on *Ulmus*, *K.*
Anthostoma melanotes (B. & Br.) Sacc., on *Fraxinus*, *M.*, turgidum (Pers.) Nits. on *Fagus*, *M.*, *A.*, *K.*
Melanconis stilbostoma (Fr.) Tul., on *Betula*, *G.*, Alni Tul. (conidial), on *Alnus*, *A.*, *G.*
Pseudovalsa lanciformis (Fr.) Ces. & de Not., on *Betula*, *G.*
Botryosphaeria Dothidea (Moug.) Ces. & de Not., on wild Rose, *M.* (no spores).
Quaternaria dissepta (Fr.) Tul., on *Ulmus*, *M.*
Diatrypella verrucaeformis (Ehrb.) Nits., on *Fagus*, *M.*, *K.*, *Alnus*, *M.*, *Corylus*, *K.*, and *Betula*, *A.*
Diatrype Stigma (Hoffm.) Fr., on *Fagus*, *M.*, *K.*, disciformis (Hoffm.) Fr., on *Fagus*, *M.*, *K.*
Sillia ferruginea (Pers.) Karst., on *Corylus*, *K.*, *G.*
Ustulina vulgaris Tul., on *Fagus*, *K.*
Hypoxylon coccineum Bull., on *Fagus*, *A.*, fuscum (Pers.) Fr., on *Alnus*, *M.*, *Corylus*, *M.*, *K.*, *G.*, and *Ilex*, *K.*, multiforme Fr., on *Aesculus*, *M.*, rubiginosum (Pers.) Fr., on *Fraxinus*, *M.*, *K.*, serpens (Pers.) Fr., on *Aesculus*, *M.*, *Fagus*, *M.*, *K.*, and *Ulmus*, *A.*, semiimmersum Nits., on *Quercus*, *A.*
Daldinia concentrica (Bolt.) Ces. & de Not., on *Fraxinus*, *K.*
Xylaria Hypoxylon (Linn.) Grev., *M.*, *A.*, *K.*, polymorpha (Pers.) Grev., *M. K.*, carpophila (Pers.) Fr., *M.*, *K.*, longipes Nits. (locality unknown).

DISCOMYCETES

Helvella crispa (Scop.) Fr., *M.*, lacunosa Afz., *M.*
Leptopodia elastica (Bull.) Boud., *M.*
Macropodia macropus (Pers.) Fuck., *K.*
Galactinia succosa (Berk.) Sacc., *M.*, badiofusca Boud., *A.*
Otidea onotica (Pers.) Fuck., *M.*, concinna Pers. *M.*, *K.*, cochleata (Linn.) Fuck., *M.*
Pustularia cupularis (Linn.) Fuck., *K.*
Peziza aurantia Pers., *M.*, *A.*
Lachnea hemisphaerica (Wigg.) Gill., *M.*
Ciliaria scutellata (Linn.) Quél., *M.*, *K.*, hirta (Schum.) Boud., *M.*
Microglossum viride (Pers.) Gill., *M.*
Leotia lubrica (Scop.) Pers., *M.*, *A.*, *K.*, *G.*, atrovirens Pers., *M.*
Cudoniella acicularis (Bull.) Schroet., *A.*
Calycella citrina (Hedw.) Quél., *M.*, *K.*
Coryne sarcoides (Jacq.) Tul., on *Fagus*, *K.*, on *Betula*, *G.*
Bulgaria inquinans (Pers.) Fr., *M.*
Polydesmia pruinosa (B. & Br.) Boud., *A.*
Orbilia xanthostigma Fr., *M.*, *A.*
Hyalinia inflatula (Karst.) Boud., *M.*
Sclerotinia Curreyana (Berk.) Karst., *G.*
Phialea firma (Pers.) Gill., *A.*
Chlorosplenium aeruginosum (Oeder) de Not., *M.*, *K.*

Helotium herbarum (Pers.) Fr., *K.*, virgultorum (Wahl.) Karst., *A.*, *K.*, fructigenum (Bull.) Fuck., *M.*
Dasyscypha virginea (Batsch) Fuck., *A.*, *K.*
Trichoscypha calycina (Schum.) Karst., *A.*, *K.*
Mollisia cinerea (Batsch) Karst., *A.*
Stegia Ilicis Fr., *K.*, *G.*
Colpoma quercinum (Pers.) Wallr., *A.*
Rhytisma acerinum (Pers.) Fr., *M.*, *A.*, *K.*

PHYCOMYCETES

Cystopus cubicus (Strauss) de Bary, on Thistle, *M.*
Phytophthora infestans (Mont.) de Bary, *A.*
Plasmopara nivea (Unger) Schroet., on *Angelica*, *M.*
Peronospora grisea Unger, *G.*, parasitica (Pers.) Tul., *A.*
Empusa Aulicae Reich., on a caterpillar, *R.*
Mucor Mucedo (Linn.) Bref., on *Comatricha nigra* Schroet., *Trichia decipiens* Macbr. and a plasmodium.
Spinellus fusiger (Link) van Tiegh., *K.*
Syzygites megalocarpus Ehrenb., *M.*, *K.*

DEUTEROMYCETES

Phomopsis coneglanensis Trav., on *Aesculus*, *M.*
Actinonema Rosae (Lib.) Fr., *A.*
Cytospora ambiens Sacc., on *Acer*, *M.*, rubescens Sacc., on *Pyrus Aucuparia*, *A.*
Dilophospora Alopecuri Fr., *A.*
Myxosporium griseum (Pers.) Sacc., on *Corylus*, *G.*
Thysidium hedericolum (de Not.) Dur. & Mont., on *Hedera*, *K.*
Libertella faginea Desm. f. minor Sacc., on *Fagus*, *K.*
Oidium alphitoides Griff. & Maubl., *M.*, *A.*
Ovularia obliqua (Cooke) Oud., *M.*, *A.*
Botrytis cinerea Pers., *M.*
Beauveria Bassiana (Berk.) Vuill., on weevil, *G.*, on caterpillar, *A.*
Acremonium album Preuss, on *Arcyria cinerea* Pers.
Verticillium botryoides Sacc., on *Leocarpus fragilis* Rost.
Ramularia Urticae Ces., *K.*, Primulae Thuem., *M.*, calcea (Desm.) Ces., *M.*, sambucina Sacc., *K.*, Taraxaci Karst., *A.*
Polythrincium Trifolii Kze., *M.*
Cladosporium herbarum (Pers.) Link, *A.*
Cercospora Mercurialis Pass., *M.*
Scolecotrichum Clavariarum (Desm.) Sacc., *M.*
Tilachlidium tomentosum (Schrad.) Lindau, on *Trichia decipiens* Macbr., and var. ovalisporum A. L. Sm., on *Perichaena corticalis* Rost.
Isaria farinosa (Dicks.) Fr., *M.*, *A.*, *K.*, *G.*, leprosa Fr., on pupa of a Lepidopteron, *M.*

MYCETOZOA

Ceratiomyxa fruticulosa Macbr.
Badhamia panicea Rost., nitens Berk.
Physarum nutans Pers., compressum A. & S.
Fuligo muscorum A. & S.
Craterium minutum Fr., leucocephalum Ditm.
Leocarpus fragilis Rost.
Diderma floriforme Pers.
Didymium difforme Duby.
Stemonitis fusca Roth.
Comatricha nigra Schroet., typhoides Rost.

Cribraria macrocarpa Schrad., argillacea Pers.
Dictydium cancellatum Macbr.
Tubifera ferruginosa Gmel.
Reticularia Lycoperdon Bull.
Lycogala epidendrum Fr.
Trichia varia Pers., decipiens Macbr., Botrytis Pers.
Arcyria cinerea Pers., incarnata Pers., denudata Wettst., pomiformis Rost.
Perichaena corticalis Rost.

LICHENS OF THE WHITBY FORAY

By H. H. KNIGHT

In districts by the sea lichens are usually plentiful, and we were disappointed in not seeing more in Mulgrave Woods. The trees were mostly bare, but many of the common species were found. *Graphis elegans* was rare; the two most noteworthy species were *Bacidia incompta* and *Rhizocarpon alboatrum*. A few saxicolous lichens were noticed on walls and stones. By the sea at Sandsend *Arthopyrenia litoralis* was collected on shells of barnacles, and *A. halodytes* on rocks.

The walls on the way to Arncliffe Wood were well covered with lichens. Among these were *Lecanora badia*, *Lecidea fuscoatra* and *L. plana*, *Biatorina lenticularis* and *Bacidia umbrina*. Arncliffe Wood is rocky, and is much better for lichens than Mulgrave. Among the lichens seen here were *Lecanora subtartarea* and *Lecanactis abietina*, the latter very abundant, and on rocks *Racodium rupestre* and *Lecidea lucida* with *Calicium arenarium* growing on the thallus.

Only a short time was available at Goathland to search for lichens, on account of rain. Here *Alectoria jubata* was growing on a tree and *Evernia furfuracea* and *Lecidea sanguinaria* on walls. On the moorlands the two species of *Lecidea*, *L. granulosa* and *L. coarctata* are common, and the var. *glebulosa* of the latter was also seen.

On walls near Whitby, *Opegrapha confluens* is common, and also the two species of *Lecanora*, *L. atra* and *L. parella*.

M. = Mulgrave Woods; *E.* = Egton; *A.* = Arncliffe Wood; *G.* = Goathland; *W.* = neighbourhood of Whitby; *S.* = Sandsend.

Calicium arenarium Nyl., *A.*
Sphaerophorus globosus Wain., *A.*
Collema cheileum Ach., *E.*, *W.*
Peltigera canina Willd., *M.*
Parmelia physodes Ach.
P. saxatilis Ach.
P. dubia Tayl.
Parmelia fuliginosa Nyl.
and var. laetevirens Nyl.
Cetraria glauca Ach., *A.*
Evernia prunastri Ach.
E. furfuracea Mann., *G.*
Ramalina siliquosa A. L. Sm., *W.*
Alectoria jubata Ach., *G.*
Xanthoria parietina Th. Fr.
Candelariella vitellina Müll.-Arg., *M.*
Physcia hispida Tuckerm., *M.*
Lecanora muralis Schaer., *E.*
L. subfusca Ach., *M.*
L. rugosa Nyl., *M.*
L. campestris B. de Lesd., *E.*
L. coilocarpa Nyl., *W.*, *G.*
L. atra Ach., *E.*, *W.*
L. galactina Ach., *M.*
L. varia Ach., *M.*
L. badia Ach., *E.*
L. subtartarea Nyl., *A.*
L. parella Ach., *E.*, *W.*
Acarospora fuscata Th. Fr., *E.*, *G.*
Pertusaria faginea Leight.
P. pertusa Dal. Tor. & Sarnth.
P. dealbata Cromb., *E.*, *G.*
P. Wulfenii DC., *M.*
Crocynia lanuginosa Hue, *A.*
Baeomyces rufus DC., *M.*, *G.*
Cladonia pyxidata Hoffm., *W.*
C. fimbriata Fr.
Racodium rupestre Pers., *A.*

Lecidea lucida Ach., *A.*
L. coarctata Nyl., *M.*, *G.*
var. glebulosa Cromb., *G.*
L. granulosa Schaer., *G.*
L. parasema Ach., *M.*
L. protrusa Fr., *E.*
L. goniophila Schaer., *E.*
L. contigua Fr., *E.*, *G.*
L. plana Nyl., *E.*, *G.*
L. fuscoatra Ach., *E.*
L. sanguinaria Ach., *G.*
Biatorina Griffithii Massal., *M.*
B. lenticularis Koerb., *E.*, *W.*
Bilimbia aromatica Jatta, *W.*
B. sabuletorum Br. & Rostr., *E. W.*,
Bacidia incompta Anzi, *M.*
B. umbrina Br. & Rostr., *E.*
Buellia canescens De Not.
B. myriocarpa Mudd., *M.*
Rhizocarpon alboatrum Th. Fr., *M.*
Lecanactis abietina Koerb., *A.*
Opegrapha confluens Stir., *W.*
O. varia Pers., *M.*
O. vulgata Ach., *M.*, *A.*
Graphis elegans Ach., *M.*, *A.*
Verrucaria nigrescens Pers., *M.*
Arthopyrenia fallax Arn., *A.*
A. litoralis A. L. Sm., *S.*
A. halodytes Oliv., *S.*

PRESIDENTIAL ADDRESS

By R. H. BIFFEN, F.R.S.

THE CEREAL RUSTS AND THEIR CONTROL

No group of fungi is as important from the economic point of view as the rusts which attack the various cereals. Its importance, too, increases as cereal cultivation, especially of wheat, becomes more widespread. The losses the rusts give rise to annually are enormous. One recent estimate puts them at 250,000,000 dollars, and still higher figures have been suggested from time to time. It is possible that much of the loss is due to the relative newness of wheat cultivation in most of the important wheat-producing countries. Australia, Canada, the United States and the Argentine have been stocked with wheats which have been grown for many centuries in the Mediterranean region, Russia or India. In their home countries they have been exposed to a process of natural selection which has fitted them more or less for their local conditions, and consequently they suffer less from rust attacks. Further, they are grown on comparatively small more or less isolated patches and do not occupy the huge continuous areas which offer ideal conditions for the spread of any fungal disease. As time goes on and the exporting countries build up new sorts of wheat better fitted for their conditions their losses will tend to diminish.

The economic position during the past decade has made it essential to investigate the possibility of minimising these losses. Wheat is a crop well suited for the pioneering agriculturist in temperate and subtropical countries, for it can be stored for long periods and readily marketed—at all events until recently. As a consequence the development of the United States, Canada, the Argentine and Australia has been dependent to a great extent on wheat production, and this still provides a very substantial portion of their incomes. Now, with prices and consequently profits declining through over-production, the risks of failures owing to attacks of rust become more serious financially, and it is being recognised that the crop may have to be abandoned in some important areas. Most of the exporting countries are therefore paying a great deal of attention to the study of these pests, with the result that our knowledge of them is increasing with gratifying rapidity. At the opening of the century the problems of rust control seemed almost unsolvable. Now it is no exaggeration to say that the solution of the most important of them is in sight, thanks to the efforts of mycologists and the colleagues whose services they have enlisted.

To-night it is proposed to give some account, necessarily a brief one,

of the story of their joint efforts. It will naturally be concerned for the most part with recent work, but here and there the earlier history of the subject will be touched on, for in some respects it is of unusual interest inasmuch as it shows how the wheat cultivators of old anticipated some of the discoveries of the scientist of to-day.

Most of us know *Puccinia graminis* as a parasite on a number of the common grasses. It cannot be considered as a rare fungus in this country. But plant pathologists do not look upon it as a serious cereal disease here. In fact it can often be searched for unsuccessfully in crops of wheat, barley and oats, and twice only have I seen a sufficiently severe attack to affect the yield appreciably. One was on an unusually late crop of wheat which had been partially crippled by bulb fly, the other on oats suffering from an attack by eelworms. The aecidial stage is very generally distributed. In parts of England such as Wiltshire and Gloucestershire, where the barberry is often particularly common in the hedgerows, it can be found in abundance every season. The cereals, however, seem none the worse for its presence. Yet such of them as have been tested are undoubtedly easily infected and very severely damaged by the fungus. For some reason which is unknown at present these crops escape the disease. This has not always been so, and, though the point cannot definitely be proved, it is well within the bounds of possibility that some of the serious famines of the fifteenth, sixteenth and seventeenth centuries were due to black rust. One unmistakable reference bearing on this point is to be found in Hartlib's *Legacy to Husbandry* (1655), in which he regrets the lack of knowledge of means for controlling the diseases of growing corn, specifying particularly smut and mildew "which ofttimes brings great calamities to these nations." That mildew was black rust becomes clear in the abundant agricultural literature of the eighteenth century. In this, though the fungal nature of the disease was unknown, practically every characteristic symptom shown by the host plant is described in detail, such as the gaping pustules and their dark powdery contents, the soft spongy straw, the lightness of the ears and the shrivelled grain. Even the extent of the losses it caused can be roughly gauged by a comparison of the number of sheaves of rusted and healthy wheat which were required to fill a bushel measure with grain. The technique of handling a rusted crop had developed and growers were familiar with the fact that in some mysterious way wheat rust was connected with barberries. At the end of the century in 1795 and 1799 two historic crop failures occurred, and from thence onwards throughout the period of the Napoleonic wars the wheat crops suffered severely, and, though the area had been increased to an extent which would normally have easily supplied the population of that period, grain had to be imported at prices which have never since been equalled. That the farmers were contending with black

rust, as redoubtable a foe as Napoleon himself, was made clear by the excellent account of the disease published by Sir Joseph Banks, the Government Botanist in 1810. For outbreaks comparable in severity with these we have now, fortunately, to look to the experience of other countries.

Puccinia graminis Pers.

The species has been recorded on about a hundred host plants. Until the end of the last century it was assumed that it could spread from any one of these to the cereals and *vice versa*, and the possibilities of control with such endless chances of infection seemed remote. Eriksson, however, showed conclusively by means of a lengthy series of inoculation experiments that this view was incorrect and that the black rust did not normally pass from wheat to oats or again from *Agrostis* or *Poa* to either of these cereals. It was welcome information to those concerned with the control of the pest, but to the mycological systematist it brought complications which made the full identification of the fungus a matter of considerable difficulty. Eriksson's investigations showed clearly that within the single species there were several specialised forms more or less sharply confined either to one or to a limited number of hosts. On the cereals three specialised forms or "biologic species" were differentiated and another seven on various grasses. Those attacking the cereals are (1) *Puccinia graminis*, f.sp. *Secalis*, (2) *P. graminis* f.sp. *Tritici* and (3) *P. graminis* f.sp. *Avenae*. The first occurs on rye and barley and a few grasses, the second primarily on wheat and rarely on the other cereals, and the third on oats and a number of grasses. Very similar results from a parallel series of investigations in Russia were obtained by Jaczewski and more recently by Tetervnikova. In America, where numerous investigations on the subject have been made, the specialisation of *P. graminis* may take place in a slightly different manner. The form *Tritici* is apparently limited to wheat, barley and a few grasses, and there is an additional form *Hordei* on barley and wheat. In general, however, there is a close parallel between the forms of this fungus in Europe and America, as would perhaps be expected if it is recalled that the cereals of the latter country are for the most part introductions from Europe.

Eriksson's work has thus shown—broadly—that each of these graminaceous genera is liable to be attacked by a specialised form of *P. graminis* more or less peculiar to itself. More recent investigations have carried the story still farther. To appreciate the facts it has to be realised that wheat, oats and barley are each large groups of more or less closely related races, varieties and forms. There are, for instance, several thousand distinct forms of wheat in cultivation in various parts of the world. They easily outnumber the species of flowering plants in

this country, and if the forms of the other cereals are included they probably outnumber the species of fungi. In considering the pathological problems associated with these crops, wheat, barley and oats cannot then be looked upon as single entities.

If uredospores are taken from a wheat *A* and applied to the foliage of one hundred distinct forms, all of them will not respond in the same fashion. Infection will result in many cases and fail in others. Where infection occurs the rust attack may be severe, moderate or slight. If now the source of the inoculum is altered by taking uredospores from another wheat *B*, grown preferably in a different locality, the infection results will probably be very different. Some of the forms which resisted the attacks of the rust from *A* will now prove susceptible, whilst forms susceptible to the rust from *A* will be resistant to that from *B*. Within the single biologic species then there are strains of rust detectable, for the most part, only by observing the reaction of a series of host plants to their attacks. Stakman and his colleagues in the United States, Goulden and other workers in the Dominion Rust Laboratory of Canada, have for the past decade been steadily investigating the flora of *P. graminis* f.sp. *Tritici*, with the result that about a hundred distinct strains of it have now been recognised. Each of these is distinguished by a numeral. Small morphological differences, mainly of spore size, exist between some of them, and there are some colour differences also, but they are inadequate for purposes of classification. As a consequence the full identification of any strain is possible only when the results of a series of inoculations on a standard series of wheat varieties is available.

At present the flora of North America is the only one which has been investigated at all comprehensively. It is known, however, that in the other wheat-growing countries where *P. graminis* is present, the biologic species does not consist of a single strain only and a few of these strains have already been shown to be identical with those of America. Some of them are undoubtedly widely distributed.

The infective capacity of each of these strains is limited to a number, often a considerable one, of forms of wheat. But owing to the number of strains few forms of wheat can be expected to be completely resistant to stem rust in all of its manifestations. The fact, however, has to be mentioned that the recognition of these strains has been accomplished by observing their effects on seedling plants growing for the most part under greenhouse conditions. Infection under these conditions may be easily effected on wheats which, when growing in the open field, appear to be highly resistant.

The existence of these numerous strains led Stakman, as early as 1918, to suspect that they owed their origin either to hybridisation, mutation or gradual adaptation. Experimental evidence is at present against the view that a strain can gradually adapt itself to and

specialise on previously resistant wheats and the known mutations are, for the most part, colour forms only. When the suggestion was made there was practically no possibility of testing it, and the most that could be said in its favour was that Stakman and Levine had obtained some circumstantial evidence that different strains could hybridise on the barberry. As hybridisation is a sexual process it was anticipated that *P. graminis*, like so many other fungi, would prove to be heterothallic. Craigie demonstrated that this was so, and his work provided the technique necessary for a controlled investigation of the subject. He showed that when a single sporidium from a germinating teleutospore infected a barberry leaf a crop of spermagonia (pycnia) and aecidia developed. The latter, however, after attaining a considerable size and undergoing differentiation into recognisable areas, remained sterile and died off, whilst the former developed normally. A multiple infection, however, gave rise to normal fertile aecidia owing to the fact that it provided the (+) and (−) or the two sexual strains necessary for the development of the sporophytic generation. The possibility of transferring spermatia (pycniospores) of one sex to an infection of the opposite sex made the way clear for actual hybridising experiments and though Craigie's results were only published in 1927 a considerable volume of evidence has accumulated already which tends to show the soundness of Stakman's and Levine's view.

They themselves attacked the problem by making crosses between two biologic species, *P. graminis Tritici* and *P. graminis Agrostidis*. Protected barberry foliage was inoculated with teleutospores from wheat and from *Agrostis alba*, and reciprocal crosses were made by transferring the spermatia-containing nectar from wheat to *Agrostis* inoculations and *vice versa*. At the same time a number of spermagonia were "selfed" by transferring nectar from one series of wheat inoculations to other wheat inoculations and similarly with *Agrostis* inoculations.

The cross made by transferring nectar from the *Agrostis* spermagonia to those of wheat produced fertile aecidia in all cases, but transfers in the opposite direction gave no results. The aecidiospores were then tested. Those arising from the selfing of wheat spermagonia gave *P. graminis Tritici* 36 only and those from the *Agrostis* spermagonia *P. graminis Agrostidis* only. The four crosses, however, produced twelve distinct strains capable of infecting wheat and none capable of infecting *Agrostis*. Of these strains three had not been found previously, one was only known to occur in Portugal and the remainder had been recorded in North America. Eight of them were produced from a single aecidium. Crosses between *P. graminis Secalis* 11 and *P. graminis Tritici* 36 also yielded a progeny differing from the parents.

Concurrently with this work the subject was being investigated by

Newton, Johnson and Brown in the Dominion Rust Laboratory. In addition to making crosses between certain strains of *P. graminis Tritici*, they sought to lay the foundations of future work on the genetics of rust by determining the constitution of a number of distinct strains. For this purpose they "selfed" eight of them, picked off the resulting aecidia before they could open and so possibly become contaminated and from these worked up stocks of uredospores for comprehensive infection trials. Of the eight strains only one, No. 9, bred true to type, the remainder producing from two to eighteen distinct strains. Of the total of thirty strains resulting from these "selfs" twelve had not been recorded previously.

The crosses between strains did not produce the wide series resulting from the "interspecific" crosses between the biologic species on wheat and *Agrostis*. Thus a cross between strains 15 and 9, the latter of which is known to be true to type, gave strain 9 only, whilst various crosses between 17 and 49, known to break up into eight and nine strains respectively, gave four strains, one only of which was known to be produced by one of the parents.

Incidentally these experiments showed that only one strain occurred in each aecidium, though a single pustule might contain a number of aecidia each capable of producing a separate strain.

It is almost inevitable that an attempt should be made to interpret these results on a Mendelian basis. But until the results of crosses made between strains known to breed true to type are available and statistical examinations of subsequent generations have been made, it is perhaps premature to do so. The occurrence of a number of strains after "selfing" a single one is thus described as segregation, the original strain being described as heterozygous, whilst the strain which breeds true (No. 9) is homozygous. Segregation follows only after sexual reproduction, and the strain keeps true to type as long as it is propagated asexually, that is by means of uredospores. An analogy may be drawn from the potato crop. This consists of an indefinite number of sorts of hybrid origin such as King Edward, Up-to-Date, Arran Comrade, etc. When propagated asexually from tubers they remain true to type, but if seeds obtained by self-pollinating are sown the progeny consists of many distinct types. It is rarely that a homozygous sort corresponding to *P. graminis Tritici* 9 by breeding true to type is found. Each type of potato owes its distinctiveness to an assembly of numerous unit characters such as colour, shape, depth of eyes, etc., and it is consequently easily recognised. In rusts the distinctiveness can be established only by means of tedious inoculation trials, for the unit characters appear to be an indefinite number of slight pathogenic differences.

Whether these phenomena are of the same nature as those occurring when crosses are made between the higher plants or not, it is clear

that the alternate host plays a part in originating strains of the stem rust. In countries where no barberries are to be found and where consequently the rust is only propagated vegetatively, it seems probable that far fewer strains will occur than in countries where there are abundant opportunities for the various strains to intercross. Australia thus should possess relatively few rust strains compared with North America and Western Europe. Further, rust species lacking an accidial stage might be expected to be either monotypic or to consist of a few strains only.

Puccinia glumarum (Schm.) Eriks. & Hen.

The commonest cereal rust in this country is the yellow rust, *P. glumarum*. Biologic species of it occur on wheat, barley and various grasses. It is common throughout Western Europe, India, and parts of Africa. It occurs also in Canada and the United States, though in neither of these countries is it, at present, a serious pest. The fungus is invariably to be found on English wheat. The attacks, however, vary greatly in their intensity. In some seasons the foliage is almost covered with the bright yellow pustules. They occur too on the glumes, within the paleae and on the grain. In others only a sparse crop of sori is to be found on the foliage. But even an intense attack rarely ruins the crop completely; at the worst the yield of grain is appreciably reduced, and that largely on account of the fact that it is ill-filled and shrivelled. The fungus lacks the killing power of *P. graminis*. As a consequence the English farmer pays comparatively little attention to it and often fails to realise that when the crop yields fall below the average, yellow rust is most generally the cause. The factors responsible for the variations in the intensity of the attack have still to be thoroughly investigated. Those associated with climate undoubtedly play an important part, for a low rainfall during the spring and a dry and warm June and July are usually associated with a light attack of rust. Soil conditions too have a marked effect. Wheat growing on poor sterile land is never seriously attacked, but strongly grown crops, particularly if forced with nitrogenous manures, may suffer severely. In fact yellow rust then becomes the most serious limiting factor the man who sets out to grow a bumper crop has to contend with.

Of great importance too is the question of variety. The majority of wheats grown here suffer, on the whole, little from rust attacks. With many of the varieties introduced for experimental purposes from India, Persia, Iraq and China the case is otherwise, for even in seasons when little yellow rust is present they may be so severely attacked that they are killed outright.

The uredo stage can generally be found if carefully searched for on the more or less procumbent foliage of wheat during the late autumn months. It persists through the winter but fails to spread much until

the crop begins to grow actively. By the middle of March the foliage may be heavily infected, but more generally this stage is not reached until the end of May.

The fungus is readily recognised by the bright cadmium-yellow colour of the uredopustules which are frequently sufficiently numerous and densely packed to cover the greater part of the leaf surface. The teleuto stage follows the uredo stage at an interval of some three weeks. It appears in the form of streaks of small black spots for the most part on the leaf sheaths. The spores remain covered by the epidermis. They do not require a resting period and are capable of immediate germination. There is, so far, no definite evidence that they play any part in the dissemination of the disease. In fact their function is unknown, for all direct infection experiments on cereals, grasses and possible alternate host plants have failed to produce either an uredo or an aecidial stage. The view has consequently grown up that this latter stage of *P. glumarum* is non-existent. But until the district of origin of wheat is known and its rust flora has been investigated the failure to demonstrate the existence of an aecidial stage may be explained as being due to the non-occurrence of the alternative host in other wheat-growing countries.

Three biologic species have been distinguished on wheat, barley and rye, one on *Elymus* and one on *Agropyrum*. That on wheat is not absolutely confined to its normal host, for it can be transferred with difficulty to both rye and barley. Whether the biologic species, in turn, consist of a number of strains has still to be investigated. Field experience with the wheat crop appears to indicate their existence and warrants a direct attack on the subject by means of controlled infection experiments.

Puccinia triticina Eriks.

Though widely distributed, the brown rust is a pest of minor importance except in the Argentine. It occurs throughout Western Europe, India, Japan, the United States and Canada. In East Africa it occurs wherever wheat is grown, contrasting strongly in this respect with *P. glumarum*, which is a serious pest at elevations of 7000–10,000 feet and *P. graminis* with an altitude range of 4000–7000 feet.

The species is confined to wheat. In this country its small brown uredosori are usually to be found about the middle of June. They generally occupy the upper surface of the leaf, whilst the succeeding teleutosori occur in a more or less linear fashion on the lower surface. Where the attack is severe the leaf sheaths and stems also carry a crop of teleutospores distinguishable from those of *P. graminis* by the fact that the pustules are not surrounded by a white frill formed by the ruptured epidermis. The aecidial stage is borne by species of *Thalictrum*.

A number of strains exist within the species, and wheats which have proved to be resistant to the attacks of this rust in England have been found to be markedly susceptible to its attacks in the United States.

Puccinia coronifera (Kleb.)

The crown rust of oats, though common in this country, is of relatively little economic importance. At least nine biologic species have been distinguished, eight of which are more or less sharply confined to such grasses as *Lolium*, *Festuca* and *Bromus*.

The orange-coloured pustules of uredospores appear late in the season on the leaves and leaf sheaths and a week or so later black teleutosori develop amongst them. After over-wintering the latter are capable of producing an aecidial stage on *Rhamnus cathartica*.

Control

Both from the practical and the scientific standpoint the part played by the barberry in the spread of black rust is still largely a matter for discussion. Two possibilities have to be considered. The barberry stage may be an essential one in the development of the fungus or it may only be facultative, with the result that the fungus can exist from year to year without passing through it. In the first case the suppression of the alternative host should definitely result in the extermination of the rust on the cereals, whilst in the second it would have no such effect. Experimental work in progress in various parts of the world is beginning to throw some light on these problems.

The eradication of the alternative host plant as will be shown later, has been a common practice for at least a century and a half and probably more. In the past it did not lead to the extirpation of the disease, though it may possibly have resulted in its partial suppression. The failure to produce the anticipated results may be accounted for by the difficulty of doing away with every infected bush occurring in a large wheat-growing area. This is discounted, however, to a certain extent by the fact that the aecidiospores do not appear to spread over a wide area. Thus there are many references in the agricultural literature of the end of the eighteenth and the beginning of the nineteenth century calling attention to the severity of rust outbreaks on wheat immediately in the neighbourhood of a barberry bush, whilst a short distance away the crop was disease free. One striking example likens the infected portion of a crop to a comet with a barberry bush as its nucleus and its fading tail pointing in the direction of the prevalent wind. This tail, the "sensible effect," extended only to some twelve yards.

Wholesale eradication of barberries has been carried out systematically for a number of years in some of the American states, and the effects have been observed as critically as possible in a vast experiment

of this kind. As time goes on and more observations are made the results should become very significant. For the present they indicate that the prevention of infection by aecidiospores leads to an increase in the yield of the crop, though it does not effectively suppress the rust. The increased yield can only be estimated. In North Dakota over a ten-year period it amounted to 17,800,000 bushels, and in thirteen other wheat-growing states to 50,419,666 bushels in the period 1915–20 and 15,920,000 bushels in the period 1921–26. The figures are impressive. Perhaps the most important point the experiment has established so far is that suppression of the barberries delays the rust outbreak for some three weeks. The healthy growing period of the crop is thus prolonged, with the result that better grain yields are secured.

Further evidence is thus provided that the aecidial stage in the life-history of the rust is not absolutely essential for its continuous existence. That it is merely facultative is further indicated by the experience of wheat-growing countries where the barberry is absent. Thus severe losses are occasionally experienced in Australia, where, apart perhaps from casual introductions of berberidaceous shrubs in gardens, the alternative host is unknown. The same is true of our newest wheat-growing colony, namely Kenya, where rust attacks are often of exceptional severity.

The recognition of the fact that black rust need not necessarily pass through its complete life-cycle at once raises the problem of how it tides over the period when no wheat plants are in existence. It has to be recognised that the climatic conditions under which wheat is grown are so extraordinarily different that the state of affairs obtaining in one country may be very different from that in another. In Kenya, for instance, uredospores are being produced continuously throughout the year in one part of the country or the other. In fact the conditions are such that in some parts of it wheat in every stage of growth from the seedling to the ripe crop can be seen on the same farm. The problem of tiding over hardly arises here. In most parts of Canada, on the other hand, the crop is cleared off by the end of August, and no wheat is available for the fungus until the following April. A comparable break exists in Australia. The same is true of India, where it has been shown, moreover, that the uredospores cannot survive the intense heat of the plains. In parts of the United States, as in this country, it is limited to a month or possibly two. This period is too short to insure the dying off of every uredospore. Succeeding crops may then become infected, and field observations have shown that the rust can be found in small quantities throughout the winter months. These traces of rust are almost certainly the actual starting-points of new local epidemics.

Two other possibilities have been suggested to account for the

sudden outbreak of the disease over wide areas. The first suggestion is due to Eriksson who considers that the wheat plant from the embryo stage onwards carries within it some of the protoplasm of the rust, which, when suitable conditions arrive, differentiates itself and gives rise directly to a mycelium and spores. As an alternative to this mycoplasm hypothesis the view has been put forward that new outbreaks are the result of infections by wind-borne uredospores. Air currents passing over rust-infested wheat in the United States would then explain the beginning of epidemics in Canada, or again a rust outbreak in the plains of India could be caused by spore-laden southerly currents from the foothills of the Himalaya. Allowing for a lag necessitated by the period between infection and the visible appearance of the rust, the first outbreaks should synchronise with the coming of southerly winds in Canada and northerly winds in the Indian plains.

The joint efforts of mycologists, meteorologists and airmen are beginning to throw light on the question whether such long-range spore dispersal does occur. Direct investigation on the subject has been carried out in the United States and also in Canada. In the former country it is only in the extreme south that the uredo stage normally over-winters and so provides a more or less continuous source of infection. The spreading of spores northwards from this centre of dispersal has now literally been followed up. As a start the dates of the first appearance of the rust in the spring were noted over wide areas to the north of Texas and correlated with meteorological conditions. They showed a clear correspondence with the first occurrence of southerly winds, the dates defining their actual course with striking accuracy. Concurrently the spore content of the air currents at various heights was investigated by exposing adhesive slides during aeroplane flights, when it was found that viable spores were present in abundance up to 12,000 feet. These were found to settle down in sufficient quantity to produce a heavy infection—for adhesive plates exposed at ground level for 24 hours trapped spores at the rate of 600 per sq. foot. Given suitable conditions for their germination then the puzzling phenomenon of the simultaneous infection of the majority of plants in a wheat field can be accounted for satisfactorily. Recent work suggests that the ideal conditions for the purpose are provided by heavy deposits of dew.

It seems possible that mankind has had to put up with the partial loss of the crop from the earliest days of wheat growing. There is, however, no direct evidence on this point. It is fair too to expect that it should exist, for the prehistoric cereals of Egypt are so perfectly preserved that if pustules were present on the glumes or straw they could be detected as easily as on freshly gathered specimens. Yet though many "finds" have been carefully examined none has yet shown any signs of infection. The same is true of the wheats of the early Iron Age,

though as the preservation of the material is not so good the evidence is less critical.

It is not until the period of written history is reached that we learn of the existence of rusts. They were then sufficiently abundant and destructive to be the bane of wheat growers. Naturally enough the epidemics were then looked upon, as even sometimes nowadays, as acts of God, and part and parcel of the routine of cultivation was to propitiate the responsible deity. At the Roman festival of the Rubigalia, wine, frankincense and the entrails of dogs and sheep were offered to insure rust-free crops.

Yet even at this period it was vaguely recognised that climatic conditions played a part in the occurrence of rust epidemics and the view that dew settling on the ears was their primary cause was generally held. This in common with much natural philosophy of a similar order was current in this country in the seventeenth century. It led directly to what appear to be the first real attempts to control the disease. Worlidge about 1620, made the interesting suggestion that the noxious dew could either be prevented from forming on the ears, or failing that, it could be removed before it caused serious damage. To prevent its formation he suggested that whenever nights promised to be "serene" the wheat fields should be covered with a cloud of smoke by means of smudge fires similar to those which in more recent days have been used to ward off slight frosts from fruit trees. Its removal was to be effected by two men holding a cord between them walking through the crop and brushing it off of the uppermost leaves and ears.

At this period too the possibilities were explored of making the crop obnoxious to the "distemper" by placing in it woollen rags steeped in a solution of salt of tartar, in white wine vinegar, or treated with pepper.

No definite progress was made with the problem of controlling rust until a century later. By the middle of the eighteenth century the accumulated experience of farmers had made it clear that in some mysterious way barberries and rust epidemics were associated. The eradication of what we now know to be the alternate host was therefore advocated, though, as it was left to the individual farmer to carry out if he believed in the story and was willing to go to the trouble, it is fairly certain that it was not effected at all thoroughly. In Massachusetts, however, where wheat was being grown on a small scale to supply the needs of the early white settlers, barberry eradication was made compulsory, and for the first time in history the control of a fungus disease by legislative action was attempted.

About this period too the fact was recognised that certain kinds of wheat were less affected by rust than others and even in rust years their yield was not seriously diminished. The first sort of which a

record appears to exist was known as "bearded wheat"—a name which now gives no clue to the actual variety. By the beginning of the nineteenth century, at a time when attacks of the black rust were exceedingly severe, the cultivation of spring wheats in place of the usual autumn wheats was recommended and very generally practised in the Eastern Counties. In *Communications to the Board of Agriculture* (1800) there is an essay on spring wheat by Peter Sers in which the statement is made that on his farm "not any of it was hurt with the fatal mildew which nearly destroyed 250 acres of winter wheat." Other writers quote similar experiences. Yet twenty years or so later the use of spring wheats seems to have become obsolete. This may have been due to their yielding capacity being less satisfactory than that of the autumn wheats, or it may be that epidemics of black rust had ceased. It is suggestive in this connection that the literature of the middle of the nineteenth century contains comparatively few references to the disease. But resistant varieties survived, and at the beginning of this century one known as "Little's anti-mildew" was still in cultivation in the East Anglian fens.

The cultivation of rapidly growing and maturing wheats still provides a useful method of minimising the losses due to stem rust. In parts of the United States, for instance, these early wheats begin to show signs of ripening by the time the rust attack is due, and though they become infected the grain has developed to such an extent that the losses are far less than would have been the case had this occurred at an earlier stage of growth. A favourite wheat for this purpose is the Canadian "Marquis" raised by Saunders. Its originator had in view the production of a sort which would be less liable to suffer from frost immediately before the harvest and which consequently would help extend the Canadian wheat area further north. It has, however, persistently spread to the south, where, susceptible as it is to stem rust, it contrives to dodge partially its attacks, much as early potatoes here dodge *Phytophthora infestans*.

The discovery of Bordeaux mixture and of other fungicides in the eighties of last century, which have done so much to control a number of serious fungal pests, has unfortunately proved of no value to the wheat grower. It is practically impossible to spray the crop efficiently, and even if it could be done the profits on wheat growing are too small to warrant any further expenditure on the crop. To the experimenter, however, the use of fungicides such as flowers of sulphur is often helpful.

The starting-point of the more recent attempts to control the various rusts of the cereals is provided by the fact that when a number of kinds, of wheat for instance, are grown under identical conditions, the responses to the attacks of the rust are very different. If, for instance, a collection of wheats is exposed to the attacks of *P. glumarum*,

some kinds will be found to be highly susceptible to attack, some moderately so, whilst a few may be found on which the fungus can make no impression. Susceptibility or resistance to the attacks of this one species does not imply that the behaviour of the wheat will be the same if exposed to the attacks of other rusts or even of other biologic forms of the same species. In fact a general capacity to resist rusts as a whole is non-existent, though an approach to it is found in *Triticum monococcum*, a species which, unfortunately, has played little if any part in the evolution of the cultivated wheats.

Researches carried out in various countries where the yellow rust is prevalent have now established the fact that highly resistant wheats are to be found in both *T. vulgare* and *T. compactum*, that is in the two groups of wheat which are suitable for bread-making. The same is true of the brown rust.

Investigations on similar lines with the far more important *P. graminis* have revealed a somewhat different state of affairs. Few, if any, wheats belonging to the bread-making (*Vulgare*) group have been found to resist the attacks of the many strains of this fungus. But some measure of resistance has been found in two other groups, *T. durum* (macaroni wheats) and *T. dicoccum* (emmer wheats). Many of the forms in these two groups are susceptible, but though pustules may be produced in abundance the plants are not crippled to anything like the same extent that a bread wheat bearing them to the same extent would be. Some few, notably the form of *T. dicoccum*, known as Khapli, are outstandingly resistant and can be cultivated with the certainty of producing a crop in even the worst of rust years.

Practically all of the wheat-growing countries of the world have now established research stations at which the hunt for resistant kinds is being systematically carried on. Up to the present, though, few have been fortunate enough to find ready-made forms suitable for their conditions of cultivation. The search is complicated by the fact that severe testing-out epidemics do not occur every year and in seasons when the rust attack is a light one moderately susceptible forms may escape entirely and for the time being be looked upon as resistant. The difficulty is overcome to a certain extent by the foundation of rust nurseries which guarantee abundant sources of infection and by growing the crops under intensive conditions of cultivation.

The finding of a resistant kind does not, however, necessarily solve the wheat grower's problem. He has the economic value of the crop to consider, and if, for instance, the yield per acre is low or the grain is a type which can only be marketed with difficulty, or if in any way it is not suitable for his conditions, then the resistant wheat will make no appeal to him. Thus, as a general rule, the resistant kinds found in the two groups *T. durum* and *T. dicoccum* have no direct economic value.

It is questionable whether the fear so often expressed that this power of resistance will break down, with the result that cereals possessing it will in time become susceptible, has any real basis of fact. A few years since there seemed to be abundant evidence that such a phenomenon occurred, but where investigation has been practicable the occurrence has been shown to be due to the attacks of fresh rust strains and not to those of the strains to which the cereals were originally known to be resistant. Thus the failure of rust-resisting Australian wheats to withstand the attacks of rust in America or South Africa where they encountered different strains is only to be expected. Unfortunately, though, little is known definitely with regard to the capacity of any forms of cereals to resist rust prior to the beginning of this century, so that historical evidence on the point is lacking. But a number of cases can be quoted of resistant wheats which have been kept under observation at experimental stations for as long as twenty-five years without any changes in their resistance being detected.

The search for cereals on which the rusts generally attacking their kind can make no impression is, however, only one stage in the problem of controlling rust. Once it was certain that resistant forms existed and that their power of resistance was a constant property which was not due simply to external conditions specially favourable to the host or unfavourable to the parasite, the next obvious step was to test the possibility of resistance and susceptibility being a pair of plant characters in the Mendelian sense. Assuming this to be so, then the possibility of definitely breeding new rust-resistant kinds was opened up. Curiously enough, this had been suggested over a hundred years ago by one of the pioneers of plant breeding, T. A. Knight. Some of the first investigations on the subject happened to be made with almost ideal material for the purpose. This consisted of two sorts of wheat, one, "American Club," with exceptional powers of resistance to the attacks of *P. glumarum*, the other, "Michigan Bronze," which though very susceptible could generally be relied upon to produce sufficient seed to keep the stock in existence from year to year. The plants of the first generation of the cross were badly rusted and comparable, as far as the number of pustules on the foliage was concerned, with "Michigan Bronze." They seeded more freely however, probably because of the extra vigour which is so often associated with first crosses. The grain was then sown on rich soil at intervals sufficiently great to avoid excessive crowding of the plants. The resulting plots consisted of a mixture of excessively rusted plants and plants on which no signs of pustules could be detected. Their proportions were as 3 : 1, that ratio being almost conclusive evidence of the simple Mendelian segregation of a pair of unit characters with rust resistance as the recessive. The grain from a large number of individual plants was then sown in separate cultures and the incidence of yellow rust

on the resulting plants noted. The cultures were found to fall into three classes: (*a*) all plants free from rust, (*b*) all plants badly rusted, (*c*) a mixture of rusted and rust-free plants, again in the proportion of three of the former to one of the latter. Such a result was to be expected on the assumption that the segregation was controlled by a single Mendelian factor. Further the fact was established that resistance and susceptibility to the attacks of *P. glumarum* were inherited independently of other plant characters. The parent wheats differed from one another in a number of features, such as the laxness and denseness of the ears, grain shape, chaff colour, time of ripening, etc., and it was found practicable to obtain all possible combinations of these characters in association with either rust resistance or rust susceptibility. A series of rust free and badly rusted cultures of apparently identical wheats was in fact grown for several years for demonstration purposes.

Several other investigations on similar lines have shown that segregation follows amongst the descendants of first generation hybrids between rust-resistant and rust-susceptible parents, though resistance is not necessarily a recessive character as in the example quoted. It is probably just as commonly inherited as a dominant character. Thus the F_1 generation of a cross between a form of *Avena sterilis* resistant to the attacks of crown rust and the very susceptible Potato oat was rust free and of its 1041 descendants 777 were resistant and 258 susceptible. The segregation is again on a simple unifactorial basis. Quite commonly too, particularly where the power of resistance is only relative and consequently none too clearly defined, the grading of the F_2 generation into distinct classes according to the response of the plants to the attacks of rust is more or less impracticable. The details of the segregation are then only disclosed by the examination of large numbers of cultures of the F_3 generation. From the practical point of view the actual details of the mode of inheritance are of secondary importance, the main point being that rust-resistant forms segregate out in the F_2 generation and can be obtained in a stable condition in subsequent generations whenever resistant and susceptible forms are interbred.

Experimentalists have now found that the production of wheats capable of resisting the onslaughts of *P. glumarum* and *P. triticina* is a comparatively simple matter.

Economic plant breeders too have taken up the problem with hopeful results. Their work inevitably requires time, for they have many other features to take into account, but already it can be said that the difficulties of the wheat grower in the Argentine, in Kenya, and in this country have been lessened by the deliberate building up of these desirable types.

P. graminis has, however, offered the pathologically minded geneticist far more complex problems than these two species. The first compli-

cation was found in the fact that the only good sources of resistance were to be found in the durum and emmer groups of wheat. Such wheats are unsuitable for various reasons for general cultivation. The transference of this feature to wheats of the vulgare group is thus essential on economic grounds. Crosses between durum and vulgare and emmer and vulgare wheats have been raised by several investigators, some with the object of studying the general phenomena of inheritance, some for cytological investigations and some in the attempt to breed rust-resisting vulgares. Their extraordinarily interesting results cannot be described here in detail, and attention can be paid only to those portions bearing most directly on rust control. The first of these is that the often partially sterile first generation hybrids give rise to a progeny consisting in the main of durum and vulgare and emmer and vulgare wheats. Rust-resistant forms occur, but for the most part this feature is confined to those forms having the durum or emmer characteristics. Its inheritance is thus not entirely independent of other characters. The linkage between it and the group of durum or emmer characters is not complete however, and a few rust-resistant forms which are in all respects true vulgare wheats have been obtained. Thus the cross between the durum Iumillo and the vulgare wheat Marquis has produced the highly resistant vulgare Marquillo and an emmer by Marquis cross two vulgare wheats, H–44–24 and Hope, which are practically immune under field conditions. Other resistant vulgare wheats have been raised at the Dominion Rust Research Laboratory by using the resistant durum Pentad as a parent. The building up of this new type of vulgare wheat has markedly altered the prospect of obtaining the numerous rust-resisting forms now required, for Marquillo, Hope and H–44–24 can be crossed easily with the other bread wheats. Their genetic constitution has already been investigated in some detail and rapid progress has been made in determining precisely the mode of inheritance of their resistance to stem rust. It has been shown that that of H–44–24 is determined by a single factor and that of Hope by two complementary factors. Further, it is inherited independently of such features as awns, pubescence of the foliage, glumes, etc. In fact there is now every indication that the plant breeder can handle resistance to stem rust as easily as any obvious morphological character. Crosses with H–44–24, for instance, result in F_2 generations in which one-quarter of the total number of plants breed true to this character. Thus large numbers of resistant forms can be obtained from which selections possessing good economic and agronomic characters can, in turn, be made.

The detailed investigation of these crosses between Hope, H–44–24, certain Pentad derivatives and some well-known vulgare wheats such as Marquis and Kanred has disclosed yet another fact of consider-

able interest. So far in describing these phenomena of inheritance no attention has been paid to the individual strains or physiological forms of *P. graminis* f.sp. *Tritici*. The resistance has in all cases been determined on field-grown mature plants. It will be convenient here to speak of this as "mature plant" resistance. The existence of the numerous strains of stem rust was determined, it will be recalled, on seedling plants, and almost from the time of their first discovery it was suspected that "seedling plant" resistance differed from that of mature plant resistance. A typical example is provided by the wheat Velvet Don which after being tested for some eighteen years in the Minnesota Rust Nursery was known to be highly resistant. Yet it was found to be susceptible to at least eleven common strains most of which were certainly present in the nursery. The same is true of Acme which is susceptible in the seedling stage to every form with which it has been inoculated but which in the field is rust free.

The mode of inheritance of seedling resistance has been investigated in some detail, for the facility with which tests could be made and useless hybrids discarded at an early stage made an obvious appeal to economic plant breeders. The most interesting fact disclosed up to the present is that a single Mendelian factor often controlled resistance to considerable groups of rust strains. This was so in the wheat Kanred, for instance, in which a single factor was proved to be responsible for the resistance to no less than eleven strains. Clearly the combination of a few such factors should result in the production of wheats capable of resisting the attacks of many of the known strains. As a method of attacking the problems of controlling rust, though, it will probably give way to the more direct technique based on mature plant resistance.

That seedling and mature plant resistance are independent of one another has been made still more clear by the investigations of Goulden and his colleagues, who examined the inheritance of the two concurrently in certain crosses. One of these was between H–44–24 and Marquis. The former parent showed seedling resistance to two groups of strains including 21 and 36. All of the cultures of the F_3 generation were tested to these two as well as being subjected to natural infection under field conditions. Thirty-six of these cultures proved resistant to seedling infection and thirty-two susceptible, but in the field both groups behaved alike and showed clean cut segregation into resistant, segregating and susceptible cultures, though opportunities for infection with strain 36 were undoubtedly available. Very similar results were obtained with a series of Pentad-vulgare derivatives.

The markedly different results obtained under greenhouse and field conditions bring into prominence the question of what resistance to the attacks of rust depends on.

Marshall Ward's work on the rust *P. dispersa* occurring on various species of *Bromus*, made it fairly certain that resistance was not determined by such features as the thickness of the cuticle, the number of stomata per unit area, the hairiness of the leaves, etc., and that some constituent of the host's cell sap or protoplasm determined whether the fungus could thrive on it or not. Biochemical attempts to identify this toxic principle have so far led to no results, neither have the attempts made to correlate the acidity of the cell sap with rust resistance. But histological evidence tends to confirm his view. If the foliage of a resistant wheat is dusted with the uredospores of a rust such as *P. glumarum* and specimens are examined microscopically at appropriate intervals it is found that the spores push their germ tubes through the stomata and in the air spaces below them form vesicles from which one or two hyphae arise. These push their way between the cells of the leaf tissue and then drive haustoria into the cells themselves. This provides the first actual contact of the mycelium with the protoplasm of the host. Its results are the death of both. The sequence of events is very different in a susceptible wheat for the penetration of the host cells is followed by the rapid growth of the fungus with, apparently, little damage to the tissues of the host itself.

If the view is accepted that the rust fails to thrive owing to the presence of a toxic substance built up by its host, then it is possible that changes in the plant's metabolism, brought about by differences in nutrition or in climatic condition, may explain the fact that the intensity of rust attacks on one and the same kind of wheat varies so greatly from season to season and even from field to field.

In districts where over-wintering of the uredo stage does not occur seasonal variations may in turn be due to the absence of the necessary inoculum or, if it has reached the crop, to its failure to bring about infection. Uredospores falling or placed on the surface of a leaf do not inevitably germinate. Their growth is very dependent on external conditions and none are less favourable than those provided by dry weather, especially when it entails long-continued closure of the stomata. On the other hand, a film of dew provides them with ideal conditions, and controlling a rust attack by preventing its formation is, perhaps, less fanciful than at first sight would appear.

OBSERVATIONS ON THE MARGIN OF *PERTUSARIA COMMUNIS* (L.) DC.*

By O. V. DARBISHIRE

(With Plates I and II)

In a previous paper, on the Lichens brought back by the British Antarctic ("Terra Nova") Expedition of 1910, I re-introduced the use of the old term protothallus ((6), p. 33) in connection with a new one, metathallus. The protothallus is the peripheral, meristematic and therefore more or less undifferentiated portion of a crustaceous lichen thallus. It consists mainly of fungal hyphae running generally in a centrifugal direction. If present at all, the algae do not yet form a definite gonidial layer. The protothallus gradually passes into the metathallus, the mature portion of the lichen thallus. This in the end exhibits the complete structural differentiation characteristic of the full grown lichen.

In 1866 Schwendener referred to the use of the terms hypothallus and protothallus or subiculum, as incorrectly applied to the margin of certain crustaceous lichens. He considered that this margin does not merely act as a lower layer on which the areolate thallus is later on developed ((21), p. 401). The so-called protothallus is nothing but a narrow marginal zone and all subsequent changes of the thallus are due to internal and not to external growth of this margin. Schwendener in fact makes it quite clear that the protothallus does not merely comprise the hypothallus before the differentiation of the areoles. It represents the whole thickness of the lichen thallus before its differentiation. His figures (Pl. IV, figs. 4, 5 and 6) of the margin of *Sporastatia Morio*, of *Rhizocarpon subconcentricum*, and of *Aspicilia calcarea*, show this distinctly. The whole mature thallus—our metathallus—has arisen by gradual growth from the whole of the protothallus. Schwendener, however, wishes to replace the word "protothallus" by "margo" or "Thallusrand." In an earlier paper he had already stated that hypothallus and protothallus were synonymous terms, and that they referred only to the first product of the germination of the spore ((19), p. 22). At a later period he regarded the protothallus as merely the peripheral part of the thallus ((20), p. 325). He mentions the margin or Thallusrand of *Pertusaria communis* and characterises it as being devoid of gonidia. He points out also that in such lichens as *Sporastatia Morio*, *Pyrenodesmia variabilis* and *P. chalybaea*,

* A preliminary account of the subject-matter of this paper was communicated to the Botanical Section at the Bristol Meeting of the British Association for the Advancement of Science on September 9th, 1930.

the gonidia never originated on the surface but always in the brown or dark blue inner hyphae. But at that time, and even in 1866, he had not yet formulated his theory of the dual nature of lichens. I have adopted the use of the term protothallus practically in the same sense as shown in the figures of Schwendener ((21), Pl. IV) though rejected by him.

The protothallus passes gradually into the metathallus. These two regions represent, however, two very distinct and well-separated portions of the crustaceous lichen thallus. The protothallus represents the meristematic and not merely embryonic condition of the mature thallus. The protothallus may also have other functions to perform. It is in intimate contact with the substratum by means of delicate fungal hyphae. It can no doubt rapidly absorb water and pass it along to the metathallus. It may also pick up algae which are ultimately incorporated in the gonidial layer. Primarily, however, it is the undifferentiated growing margin of the whole crustaceous lichen thallus.

The words protothallus, hypothallus and margin, have been applied by different lichenologists in various ways, and it would lead too far to give a further historical account of their use and abuse. A few cases only are mentioned to show the confusion that exists regarding the use of these terms. Neubner (15) rejects the use of the terms hypothallus, protothallus and "Vorlager," all of which he considers to be synonyms, at any rate in the Caliciaceae, as the smallest beginning of the lichen here is already a thallus and not at first a protothallus. Neubner clearly does not distinguish between hypothallus and protothallus. Harmand (12) defines the hypothallus, as the "couche inférieure du thalle, composée d'hyphes et visible au bord d'un grand nombre de lichens crustacés." This very correctly represents the generally accepted conventional use of the concept hypothallus. Hue (13) calls the well-marked margin of a crustaceous lichen the hypothallus, as for example in *Lecidea Petermannii*; but the use in this sense is incorrect. The hypothallus is that part only of the mature thallus which is in the closest touch with the substratum. At the margin the hypothallus does not comprise the whole thickness of the thallus as is so frequently thought. In the meristematic margin—our protothallus—the hypothallus is not yet properly differentiated. Miss A. L. Smith (23) speaks of the "hypothallus or prothallus" as being the margin of a thallus. The distinct margin seen in so many crustaceous lichens, especially in rock-loving species, is entirely protothallus in our sense. Occasionally differently coloured zones may be distinguished in the protothallus. The outermost edge of the protothallus would then naturally be called the margin of the protothallus. Stahlecker (24) distinguishes the praecurrent hyphae of certain crustaceous rock lichens as a definite portion of the thallus, and they

evidently correspond to the protothallus as defined in this paper. Bachmann (1) makes use of the customary word "Vorlager," and of prothallus for what I call protothallus. Beckmann (2) discusses at some length the use of the terms hypothallus and protothallus. He says that very few crustaceous lichens have a "genuine protothallus," that is a mycelium formed by the germination of a spore, and on which the real thallus is developed later. In some lichens this protothallus has unlimited marginal growth. I am in complete agreement with Beckmann's definition. I consider, however, that the margin may be regarded as a protothallus in most, if not all crustaceous lichens. Zukal (27) supplies the least satisfactory definitions of the terms under discussion. His hypothallus includes our protothallus (or prothallus) and also the tissues here called the hypothallus. These tissues I would consider to be of secondary growth, and for that reason they would not form part of the protothallus. Krabbe (14) applies the term protothallus to the first formed horizontal thallus of *Cladonia*. It is, however, a mature organ, though it does not persist in all species. In describing the general morphology of the species of *Cladonia*, Wainio (26) distinguishes the hypothallus from the thallus, and the latter he divides into the horizontal thallus primarius and the vertical podetium. There is no doubt in my mind that his hypothallus in this fruticulose genus would correspond to our protothallus, should the latter term be applicable to fruticulose lichens, just as I have made use of it in the foliaceous lichen genus *Peltigera* (7).

The actively growing protothallus of *Pertusaria communis* (L.) DC., the subject of this paper, was described, incidentally, as margin, by me in 1897. It is true that in 1876, Frank gave an account of the margin (or protothallus) of *Variolaria communis*. Under this name, however, he is undoubtedly referring either to *Variolaria amara* Ach., or to *V. globulifera* Turn. More recently Nienburg (16) has described certain phenomena observed in the protothallus of a species of *Pertusaria*. He does not name the species, but it would appear that it is also a species of *Variolaria*. The genus *Variolaria* is, however, not now generally separated from the genus *Pertusaria*. The three papers mentioned will be dealt with in the general discussion at the end of this paper.

Bitter (3) has discussed in great detail certain phases and activities of the margin of *Variolaria globulifera*, *V. amara*, and *Pertusaria communis*. But his observations and remarks are not directly concerned with the points raised in this communication.

The Protothallus of *Pertusaria communis* (L.) DC.

Pertusaria communis (L.) DC. is one of our commonest bark-loving crustaceous lichens. Two parts are readily distinguished in the thallus: the protothallus forms the immature growing margin of the

whole thallus; the metathallus forms the mature and more central portion of the thallus, though it need not necessarily have ceased growing altogether. Secondary growth occurs freely in the metathallus of every crustaceous lichen.

In this paper I am specially concerned with the protothallus, its growth and structure. Fresh material was used for examination, directly for hand sections, or fixed with weak Flemming for microtome sections. Sections were mounted in glycerine jelly to which a trace of gentian violet had been added, or in Canada balsam after staining with iron-alum-haematoxylin and counterstaining with eosin. Cedarwood oil was used for preparing the material for embedding in fairly hard paraffin.

The protothallus of *Pertusaria communis* consists of a mass of hyphae which show practically no differentiation and run out in a centrifugal direction (Pl. I, figs. 1 and 2). There are no air spaces in this tissue, and the hyphae are embedded in a matrix which very readily absorbs water, and covers the whole edge of the growing margin with a thick and rather tough limiting membrane. This clearly marked limiting membrane is pierced singly at first by the tips of the advancing hyphae. More matter is then secreted and the matrix extends and at once exhibits on the outside the new tough limiting membrane (Pl. I, fig. 2). The old limiting membrane persists for some time after the growing hyphae have passed it (Pl. I, figs. 1 and 2). I (5) have observed as many as three concentric lines in addition to the last formed limiting membrane actually on the outside of the matrix, representing apparently as many older limiting membranes. Gradually these lines disappear, as they are seen only in the marginal portions of the protothallus. I cannot but believe that they represent periodic growth lines, though it is impossible to say as yet what the duration of the "period" is. The material that provided the sections on which the drawings for Pl. I, figs. 1 and 2, were based, was collected from an oak-bole near Bristol, on November 18th, 1928. The protothallus might well have been growing actively at that time. In the leafless condition of the host-tree the lichen would receive plenty of light, and would thus be stimulated to vigorous growth. At another period under less favourable conditions growth might be retarded. In this way annual or other zones of growth might be produced. In one instance the outer fringe measured about 12 μ in depth, with a distance of 50 to 60 μ between it and the next oldest limiting membrane which was about the same distance further back. In some portions of the protothallus, possibly owing to very active centrifugal growth of the hyphae or complete cessation of growth, no limiting membrane could be distinguished at all, except the outermost one. Variations of this kind occur in the same material and even in the same set of microtome sections.

The marginal hyphae seem first to break through the outer limiting membrane near the upper portion of the edge of the protothallus. The new limiting membrane then seems to develop first at this point, as one would expect. Gradually the increased activity of the upper marginal hyphae spreads to the lower portions of the protothallus and the forward growth becomes more general. At first only a few hyphae push out beyond the last limiting membrane. The tip of each such hypha is well rounded off and dome-shaped (Pl. I, fig. 2). The protoplasmic contents of these apical cells are clear at the distal end, but very dense at the proximal end. The hyphae at this point are growing actively and no doubt secreting the matrix in which they come to be embedded. No doubt, too, they absorb water for the benefit of the lichen thallus generally. At the actual margin of the protothallus the hyphae exhibit no structural differentiation. On the extreme upper side of the margin, however, the hyphae soon reduce the rate at which they are growing. They lag behind the next lower marginal hyphae. Judging by the way the older limiting membranes run, these uppermost hyphae appear even to lie actually outside the thicker and more distinct portions of the limiting membrane (Pl. I, fig. 2). They are supplied with less food than the lower hyphae, their diameter is reduced and their cells are generally shorter. Their rate of growth is much reduced. In due course these hyphae will form the primary cortex, the hyphae of which retain for some time the power to grow out more or less actively at their distal end.

The more medianly placed hyphae of the protothallus are seen to run more or less regularly, parallel to the general surface of the substratum. Certain of these hyphae swing round and turn up from the median region towards the upper surface of the protothallus. This kind of growth movement was described by me in a former paper (5). These hyphae give rise to the hyphae referred to in the previous paragraph as forming the primary cortex. Other hyphae turn down towards the lower side of the protothallus. New lateral hyphae are being formed actively in this median portion of the protothallus, branching taking place at the distal ends of the cells. Secondary connections are formed between the cells of neighbouring hyphae. All the cells are rich in cytoplasmic contents, and the absence of vacuoles gives the typical appearance of meristematic tissue.

The hyphae which are gradually turning towards the lower side of the thallus also, gradually reduce their rate of growth though their girth does not generally become reduced. They apply themselves very closely to the substratum. They penetrate into any cracks and crevices in the bark without apparently breaking it up. Foreign lichen thalli grown over by the protothallus of *Pertusaria communis* may be killed, possibly by being deprived of the access of the necessary air, light and water. The attacking lichen does not, however, seem to make use of

the destroyed lichen as a source of food. The lower hyphae of the protothallus will in due course form the hypothallus of the mature metathallus. No doubt they also retain the faculty to grow out again should occasion demand, but such occasions will only very rarely present themselves.

From the medianly placed hyphae of the protothallus the hyphae of the medullary layers of the metathallus arise. These hyphae can be followed right up to the marginal portion of the protothallus from the more central portions of the metathallus. They no doubt act as conducting hyphae by which water absorbed at the margin can be conducted to the metathallus. Fairly early then at the growing portion of the protothallus of *Pertusaria communis* we can observe the first differentiation of primary cortex, primary medulla and primary hypothallus.

It appears certain that the protothallus behaves like all meristematic tissues of any ordinary green land plant. Its constituent cells are very sensitive—however selectively—to certain external stimuli. On the lower side of the margin a soft substratum will induce a single hypha to grow well out beyond the general limit of the hypothallus (Pl. II, fig. 2). Open dead cells of a corky substratum will be entered, or the thallus of a lichen which has become overgrown will be penetrated deeply.

We have clear evidence that the thin and slowly growing hyphae of the upper side of the protothallus are very sensitive to certain stimuli. They remain potentially active and continue to grow slightly for some time. They rise at an angle of about 15° to 25° with the horizontal median hyphae, and run out on the upper side of the protothallus as already mentioned. This is seen to be so at even some distance from the actual margin, right up to the point where the gonidial layer is well established. They form the primary cortex which gradually dies down and is in the end replaced by the secondary cortex arising from the hyphae found among the gonidia of the gonidial layer. The hyphae of the secondary cortex stand up more or less at right angles to the surface of the thallus. The single hyphae of the primary cortex grow mainly by their tips, but at this point the thallus as a whole does not increase in thickness to any extent as the main mass of inner hyphae are growing forward more rapidly. It is in this way that the hyphae of the primary cortex lag behind the general growth of the protothallus. Generally the protothallus gradually becomes shallower as it passes into the metathallus (Pl. I, fig. 1). The subsequent increase in thickness of the metathallus is due to the gradual development and growth in thickness of the secondary cortex, of the whole gonidial layer and the loosening out of the lower medullary and hypothallus layers, as far as the latter have not penetrated into the substratum. The loosening of the medullary layers is

associated with the extension of air passages which are of importance for the welfare of the gonidia (Pl. I, fig. 1).

Frequently single cells or groups of cells of a species of *Cystococcus* are found on the upper side of the most recently differentiated primary cortical cells. The presence of these algae affects the sensitive hyphae of the primary cortex very markedly. The latter are stimulated to growth in the immediate neighbourhood of the algae. They give off short branches which surround the algae and grow in between the separate cells of an algal group (Pl. I, figs. 3 and 4). Not only do the fungal hyphae grow actively but the algae may do the same. The fungal hyphae grow out and beyond the groups of algae they have surrounded and engulfed. The general direction of growth of these hyphae, after they have passed the algae they have been stimulated to surround, resembles that of the other hyphae of the primary cortex (Pl. I, fig. 4). They still make an angle of about 15° to 25° with the general direction of the horizontal median hyphae. Slowly the captured algae—singly or in groups—are transferred from the outer and upper side of the protothallus to the inner lower portions by the following simple process. The tips of all the hyphae of the primary cortex are growing slowly, just as are the hyphae which engulfed the algae. The primary cortex is thus growing over these algal cells which are therefore lowered into the tissues of the thallus and become embedded in the fungal tissue of the protothallus, remaining in close contact with the hyphae which surrounded them on their entry into the lichen thallus. These hyphae at first sight appear to end blindly where their distal ends are in touch with the algae, but they do not actually do so, as they really bend round the algal cells and then continue their way towards the upper side of the thallus. There is a slight gap on the distal side of the algal group, before the hyphae meet again after passing the algae (Pl. II, fig. 1). The hyphae in closest touch with the algae on their proximal end do not at first appear to have undergone any change. As the algae are gradually transferred from the upper side and lowered into the tissues of the thallus the hyphae at the proximal end of the algae undergo a remarkable and definite change. They swell up and become charged with cytoplasm to a striking extent. No doubt the algae in this way obtain a good supply of food. They have been cut off from their usual supply of water and food on entering the lichen-thallus. The food in the hyphae is therefore tapped. The accumulation of cytoplasm in these hyphae may be due to the direct stimulus of the algae or it may be a mechanical one, the cytoplasm being held up in its course along the hyphae by the algae pressing against them. These cells closely packed with cytoplasm do not appear till the algae have been lowered some little distance into the thallus. It is generally an easy matter to trace the hyphae whose end cells show the remarkable appearance just de-

scribed, continuously into the more medianly placed hyphae running distinctly in a general centrifugal direction (Pl. II, fig. 1).

The algae which I have seen to be engulfed in the way just described, undoubtedly belong to *Cystococcus humicola*, as defined by Treboux (25). They vary in size, but they are in all respects indistinguishable from the algae found in the well-developed gonidial layer. In both it is easy to make out the single peripheral nucleus which is about 0·3 μ in diameter, and the single pyrenoid in the centre of the cell and chromatophore (Pl. II, fig. 4, the single gonidium seen furthest to the right). The single pyrenoid measures about 1–1·5 μ in diameter. This description fits in with that of Treboux. The relative position of nucleus and pyrenoid in *Cystococcus* as described here was first pointed out by Dangeard in 1894. Paulson and Hastings (18) are of opinion that the nucleus in *Cystococcus humicola* Naeg. is centrally placed, and that the organ near the edge of the cell is probably the centrosome. My observations point to the view of Dangeard being the more correct.

In all regions the algae may undergo division; the resulting daughter cells are smaller than the mother cells which gave rise to them. Some of the bigger algal cells seem not to stain very deeply. This appears to be the stage preceding division, termed sporulation in the gonidia of *Evernia prunastri* by Paulson (17). It is met with in every portion of the gonidial layer. The gonidia in close touch with the richly cytoplasmic hyphal cells are generally nearly spherical. They do not as a rule show any signs of compression in any direction, though very occasionally they appear to show some elongation parallel to the general direction of the hyphae by which they are surrounded.

The protothallus as a whole now generally becomes less deep (Pl. I, fig. 1). At this point any algae which have entered the margin of the protothallus will have reached their lowest level. The hyphal cells originally filled with cytoplasm have become less conspicuous as regards their cytoplasmic contents, though in size they have altered but little. The algae are growing and dividing actively, and the hyphae too are growing and branching actively. They are now forming the loose fungal tissue characteristic of the gonidial layer. Air spaces are found below and among the gonidia. Above them the tissue is without any air spaces. This is still the primary cortex. The inner hyphae of the primary cortex seem to add a certain amount to the thickness of their layer and thus to the general thickness of the whole thallus, by branching and growing out slightly. The regular course of the outer hyphae of the primary cortex can still be distinguished. The angle made with the substratum is apt to become smaller and smaller.

The groups of algae taken in by the protothallus are now gradually raised up to the level of the gonidial layer owing to the changes which

take place in the medullary and hypothallic layers as mentioned previously. The hyphae enclosing each gonidial group at first run in a very regular manner (Pl. I, figs. 1, 3 and Pl. II, fig. 4). They come from the more median portions of the thallus of the lichen and bend round the distal and proximal ends of the gonidial groups and finally reach the surface to form the primary cortex, which originated near the margin of the protothallus. The space occupied by the gonidia thus appears somewhat diamond-shaped in a vertical and radial section. In this way the gonidia are at first covered by the primary cortex. Soon, however, the intergonidial hyphae growing very actively straight up towards the primary cortex, push their way into the hyphae of this layer (Pl. II, figs. 3 and 5). The latter become drawn out and stretched, and not being able any longer to continue growth are torn across. The primary cortex is in this way gradually got rid of and replaced by the secondary cortex which has grown up from the intergonidial and infragonidial hyphae. By this time the thallus has lost all its primary features and we have before us the metathallus in which every phenomenon of growth is secondary in character. The gonidial colonies continue to grow actively by increasing slightly in depth but mainly by horizontal extension in all directions (Pl. II, fig. 5). Fresh hyphae are continually growing in among the younger hyphae. The secondary cortex extends considerably and the smooth surface of the primary cortex gives way to the more uneven surface of the secondary cortex. This is brought about by new hyphae forcing their way in between the older hyphae of the secondary cortex and thus increasing the surface of the latter.

The algae of the gonidial layer may increase in number by the propagation of the algal cells already in the gonidial layer. The gonidial layer in this way as a whole slowly extends horizontally in all directions. Gonidia from this layer, as far as I have been able to see, do not enter the undifferentiated tissues of the protothallus from the mature metathallus. New algae destined to be added to the gonidial layers of the metathallus may, however, be engulfed by the sensitive hyphae of the upper side of the protothallus. In *Pertusaria communis*, I have not noticed algae being caught up by the actual face of the margin of the protothallus. This may possibly be due to the matrix in which the marginal hyphae are embedded being limited on its outer side at this point by the tough limiting membrane already mentioned. The more delicate hyphae of the primary cortex are also embedded in a common matrix, but this does not appear to be limited by any tough membrane (Pl. I, fig. 2). Algae may thus be able to stimulate the hyphae more effectively.

To a limited extent algae may apparently be picked up and taken in by the hyphae of the underside of the protothallus (Pl. II, fig. 2). After being engulfed on the underside the hyphal cells on the proximal

side of the algae have the same kind of rich cytoplasmic contents as with the algae taken in from the upper side. The algae taken in from below are gradually raised up to the level of the normal gonidial layer. I do not consider that the increase of algae in the gonidial layer is mainly due to anything but the vegetative division of the ordinary gonidial cells. Only to a limited extent is it due to algae being engulfed by the delicate hyphae of the protothallus, and this again chiefly on its upper side by hyphae of the primary cortex. A striking feature of the protothallus is the regularity of the course of the hyphae of the primary cortex, medulla and hypothallus, before the differentiation of the tissues of the metathallus has commenced.

Discussion and criticisms

In a paper published in 1876, Frank gave a very interesting account of the biology and growth of lichens of the simplest crustaceous type. As I am concerned in this paper more with the detailed examination of one species, I will refer only to Frank's observations on *Variolaria communis*. As I stated earlier in this paper, there is no doubt that his material belonged to *Variolaria globulifera* or *V. amara*. He describes the structure of the metathallus quite correctly. He finds the margin (*i.e.* our protothallus), to be devoid of gonidia except for a few single algae cells here and there. A horizontal section showed him that these single algal cells were situated at the distal ends of a group of much twisted hyphae which narrowed down to a point where they were in close touch with the algal cells. These hyphae he considered were derived directly from similar hyphae found among the algae of the normal gonidial layers. They had in fact grown out towards the alga-free margin and pushed before them single algal cells derived from the gonidial layer. A single algal cell pushed forward in this way into the margin would in due course give rise to one of the groups of gonidia of which the whole gonidial layer is built up. The gonidia thus picked out from the gonidial layer and pushed forward towards the margin measured 6–7·3 μ in diameter according to Frank, and the gonidia of the mature thallus 8·4–16·8 μ in diameter. Frank observed the engulfing of algal cells and other foreign bodies by the hyphae of the margin. But algae taken into the thallus in this way die off and never act as gonidia. He therefore comes to the conclusion that the algae found in the gonidial layer represent algae which are specially adapted to acting as partners of fungi in a lichen. Frank's material consisted of soraliferous specimens. He concludes that gonidia are algal cells which for untold generations have lived in lichen thalli as gonidia. The soredium, in his opinion, provides the strongest evidence in favour and support of this theory. In the soredium both alga and fungus exhibit the special adaptation of the lichen symbiosis.

More recently, in 1917, Nienburg examined and described in an interesting paper the activities of the growing margin of an unnamed species of *Pertusaria* in order to determine the origin of the gonidia in the gonidial layer. He refers to the results obtained by Frank and myself. He wished, however, to reinvestigate the relation of alga to fungus in the lichen, in order to show, like Frank, that the algae, and not only the lichen fungus, have become adapted to act as partners in the compound organism known as a lichen. He therefore rejected the view that algae might be taken in by the lichen from the outside, as stated by me (5). The gonidia in the gonidial layer of a lichen, according to his theory, are always derived from parent cells which have already been acting as lichen gonidia for countless generations. Nienburg then goes on to describe the origin of scattered algal cells in the margin (his "Thallusrand," and our protothallus). He figures and describes quite correctly the single algal cells or groups of algal cells found in the marginal tissues, at the distal end of a group of hyphal cells densely filled with cytoplasm. To these swollen hyphae he applies the name of push-hyphae or "Schiebehyphen," as he considers that they have removed single gonidia from the mature gonidial layer and pushed them into the margin which still has no gonidia. The hyphae seize on single gonidia, bring them down from the high level of the gonidial layer, and then raise them again into the still undifferentiated portions of the protothallus. I can find no evidence in support of this view. If the algal cells were being pushed forward one would expect to find them flattened out transversely to the direction in which they were being pushed. But that is not always so or even generally so. As a rule the gonidia are as nearly spherical as possible. They may even be pressed flat in the opposite direction; Nienburg himself figures such a case ((16), Pl. V, figs. 1 and 2). The small spaces at the distal end of the algal group which can generally be well seen (Pl. II, fig. 1) are figured and described by Nienburg, and they are in my opinion simply due to the hyphae passing round the algae and then continuing their straight course in a general direction towards the primary cortex. At the proximal end of the algae the fungal cells are naturally in closer touch with the algae than at the other end when they have passed round the algae. Nienburg lays stress on the push-hyphae being densely filled with cytoplasm, though pressure is best exerted by cells not filled with cytoplasm but with little cytoplasm and extensive vacuole space by which to exercise osmotic pressure. If the hyphae referred to as push-hyphae did really act as such they must actually grow forward at a rate greater than that of the neighbouring hyphae. No extensive centrifugal growth of all the hyphae of the thallus takes place at the point where, according to Nienburg, the work of the push-hyphae would be supposed to begin. The push-hyphae would therefore have to grow more rapidly than their neighbours.

There is no evidence of such growth. The general direction of the push-hyphae of Nienburg is such that it fits in well with the general direction of the other hyphae of the protothallus. If the hyphae had originated at a point where the gonidial layer is already established and had then made their way towards the margin, the direction of the hyphae would not be parallel to the general direction of most of the other hyphae but at some angle to them. The push-hyphae would grow across the other hyphae. I have already pointed out how regular the course of all the hyphae is in the region of the protothallus.

Nienburg's travelling algae ("Wanderalgen") or the algae which have been taken from the gonidial layer and pushed into the protothallus, do not appear to differ in any way from the ordinary gonidia of the metathallus. The largest in all cases are about 5–7 μ in diameter. In structure they are alike. I cannot again quite see how single algal cells can be pushed by hyphae for a distance of over 0·5 mm. as Nienburg's figures seem to indicate. I quite realise that his Fig. 2 is intended to be diagrammatic, and I do not consider that the protothallus passes quite as abruptly into the metathallus and its secondary cortex, as Nienburg's figures might lead one to suppose.

Nienburg maintains that algae engulfed by the fungus at the margin of the thallus look diseased and unhealthy. I have not come across such algae. In fact I have not yet found any dead or diseased algae in the marginal portion of the protothallus, at any rate in *Pertusaria communis*. Nienburg's dualistic theory of the lichen symbiosis, to which he applies the old special term of helotism, looks upon both the gonidia and the fungus as lichen constituents of long standing, just as Frank does. There is no doubt that the fungus is not able to lead a separate existence, *i.e.* without being associated with algae. My observations, however, show that in *Pertusaria communis* some of the algae found in the gonidial layer may have come from the outside of the lichen during its life. These algae will presumably not previously have acted as gonidia in any lichen. It is of course quite possible that for some reason no algae may be present and thus offer themselves for engulfment by the protothallus. If so, we should have an explanation of the fact that the protothallus is often quite devoid of any algal cells over a considerable distance. The new tissues being added to the metathallus would then be supplied with gonidia by the simple extension of the already existing gonidial layer through normal vegetative division. I have seen no evidence that this growth of the gonidial layer extends right into the marginal portion of the protothallus.

Nienburg has practically repeated Frank's investigations and of course was aided by more modern methods of technique in staining and preparation. His description of the protothallus of *Pertusaria* or *Variolaria* is therefore naturally more correct than that of Frank. He really restates Frank's views that the gonidial layer is alone respon-

sible for the supply of green cells to the otherwise undifferentiated protothallus. No algae are for this purpose taken in by the margin of the lichen. I would like to lay stress on the accuracy of Nienburg's figures. Nienburg maintains that the travelling algae are larger than the normal gonidia. Frank found that they were half their size. I find no difference, both varying within the same limits.

Nienburg maintains that if my view is correct that algae may occasionally be taken in at the margin to be added to the gonidial layer, or rather if even some of the healthy algae found in the protothallus have not been derived from the gonidial layer of the metathallus, it is time to consider whether the algae found in the protothallus have not been formed at and from the tips of some of the hyphae, as Elfving (9) would maintain. I consider that this conclusion is not justified. In any case I believe that I have shown that certain algae may reach the gonidial layer after having entered the margin of the protothallus, and that these algae may help to extend the gonidial layer.

The taking in of algae at the margin of a crustaceous lichen was described by me in 1897 (5) for *Pertusaria communis* (L.) DC. and *Variolaria globulifera* Turn. I have nothing to add to the description then given apart from what I have said in this paper. The observations on the taking in of algae at the protothallus were made incidentally.

The taking in of algae at the marginal portion of the thallus has been mentioned incidentally by many observers, but I do not intend to quote them here. Referring to the margin of the thallus of the Danish species of *Bilimbia*, Galløe (11) states that it represents "the meristem of the lichen, which increases its area and captures algae. Each granule has undoubtedly been formed round an alga or group of algae." In talking about the Danish species of the genus *Bacidia*, Galløe says: "During its growth over the substratum the mycelial margin of the thallus is continually occupied in capturing algae partly resting upon the substratum, partly coming down upon the surface of the thallus with the dust from the air."

The taking in of algae or the intrusion of algae into the thallus is known to occur regularly in those lichens which possess cephalodia. A typical example of this is found in *Peltigera aphthosa* (8). Specimens of a *Nostoc* reach the surface of the lichen in the neighbourhood of the growing margin. The cortical hyphae are sensitive to the touch of these cells and immediately surround them and under the influence of the *Nostoc* cells the fungal hyphae build up the elaborate structures known as cephalodia. The outer cortical cells are not sensitive to the touch of these *Nostoc* cells further back from the margin. Thus new cephalodia are formed only in regular succession at the marginal portion of the thallus. The normal gonidia of this species of *Peltigera* belong to the Chlorophyceae.

It is with some hesitation that I venture to quote an observation made by Galløe in the third volume of his monograph on the Danish lichens which I have seen in proof*. In the description of the Plate 78, fig. 206, of *Rhizocarpon obscuratum* he writes, "a gonidial alga which has fallen on to the surface of the thallus, has been captured at the extreme right of the margin. This is the first irrefutable observation of this phenomenon, the existence of which has hitherto been only surmised but scarcely ever proved with any certainty." Galløe too takes up an attitude opposed to that of Nienburg and his theory of the function of the richly cytoplasmic hyphal cells at the proximal end of the groups of algae found in the protothallus.

In this paper I lay claim to have established the fact that algae may enter the marginal portion of the protothallus of *Pertusaria communis*, and in the end, form part of the gonidial layer. In this species the algae of the gonidial layer need not necessarily all have originated from older cells of the gonidial layer. They need not all have acted as gonidia before. They can in fact play their part as casuals in the lichen just as well as the fungi which are the habituals of the lichen partnership.

Very briefly in a paper just quoted on the cephalodia of *Peltigera aphthosa*, I referred to the relation between gonidia and lichen fungus. The algal gonidia are the passive but governing partners in the lichen symbiosis, and the fungi the active building partners. The shape, form and structure of the lichen is mainly due to the influence of the algae on the fungus. The latter is adapted to responding to this influence. In that paper I also mentioned that we have to look upon the relationship of the two organisms constituting the lichen from three points of view.

From a purely anatomical point of view the lichen fungus can be considered to be parasitic on the algal gonidia, just as the gonidia can be considered to be parasitic on the lichen fungus. It is a case of mutual parasitism. From a biological point of view, it is clear that this association of alga and fungus has produced an organisation which works perfectly and efficiently. The lichen is as highly organised in a way as any ordinary green land plant.

Looked at from a physiological point of view, the general principle underlying the mechanism of this working together is seen to be simple. The green alga, by its need for air, light, water, and food material, influences the growth and general activities of the fungal hyphae in such a way that these wants are satisfied. If they are not satisfied it is the lichen that dies and not as a rule the alga or fungus.

This relationship is well illustrated by the example of the algae entering the protothallus of *Pertusaria communis*. On their first contact with the fungus the foreign algae stimulate the fungal hyphae to

* Since published.

increased activity in a special direction. That is the mechanism that leads ultimately to the building up of the lichen. The alga obtains from the fungus or through its agency its whole food supply and its water supply is stored and protected. It is clearly a parasite on the fungus. The fungus obtains very much—how much we do not know—of its food from the alga or again through its agency. It is parasitic on the alga. Mutual parasitism is established at once on contact of the green alga with the colourless fungus. Physiological control is thus also established immediately, by the alga over the fungus. The biological result is the green lichen. There is one very striking difference from the green phanerogamic land plant. Structurally we get considerable differentiation of the tissues in the lichen thallus. But the tissues exhibiting this structural differentiation have not by tradition become morphologically fixed. The medullary layer is not separated morphologically from the secondary cortex as rigidly in the lichen as epidermis, cortex and stele are separated from one another in the green flowering plant.

Summary of results

1. The whole thallus of *Pertusaria communis* (L.) DC. can be separated into a meristematic protothallus and a mature metathallus. The former consists of primary structures which gradually become differentiated into the various tissues of the metathallus.

2. In the mature metathallus cortex, gonidial layer, medulla and hypothallus can be differentiated. All these mature tissues have been derived from the meristematic protothallus.

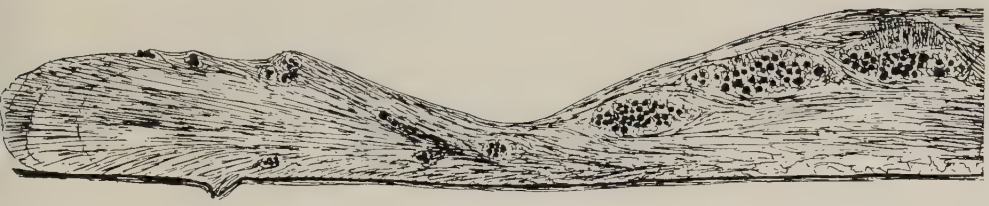
3. The gonidial layer grows in extent mainly by the vegetative propagation of its gonidia. It, however, may also grow by the addition of new algae which have entered the margin of the protothallus through the activity of the hyphae of the protothallus stimulated by the algae.

4. The algae in a lichen are not necessarily specially adapted to act as symbionts; the fungi probably are.

5. The lichen symbiosis in every case should be studied from an anatomical, a biological and a physiological point of view. The lichen is an example of mutual parasitism, where by the influence of green cells on colourless hyphae the green lichen has been built up.

6. I consider that the pushing hyphae ("Schiebehyphen") and travelling algae ("Wanderalgen") of Frank and Nienburg do not exist with the function ascribed to them, at any rate in *Pertusaria communis* (L.) DC., and its allies.

The thanks of the author are due to the Colston Research Society for a contribution towards the cost of publishing this paper.



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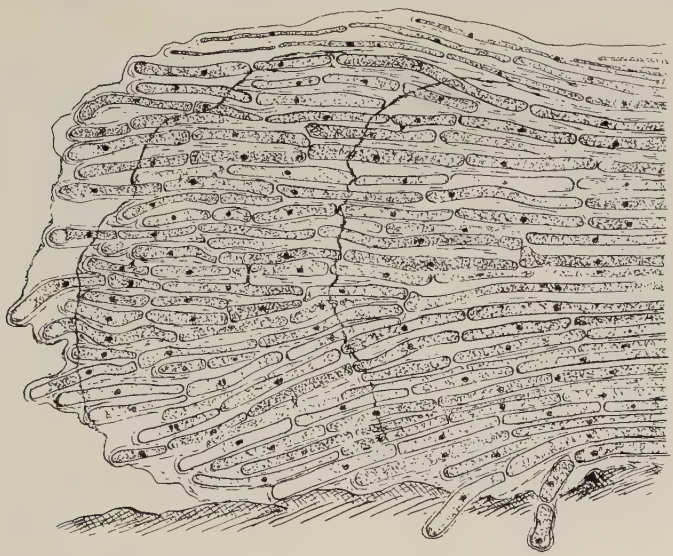

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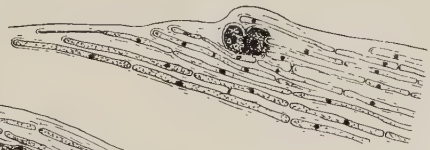

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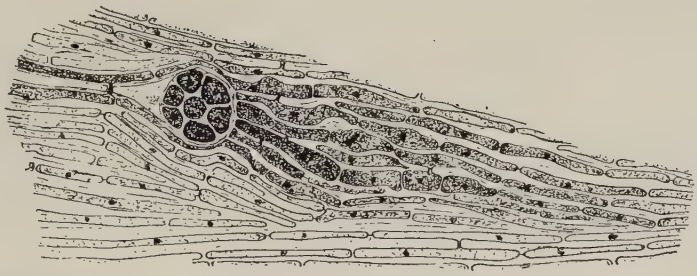

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Pertusaria communis (L.) DC.

EXPLANATION OF PLATES I AND II

Plate I

Fig. 1. Diagrammatic general view of the protothallus and a portion of the metathallus. The growing hyphae of the extreme margin are on the left, and on the upper side are noticed the more slowly growing hyphae of the primary cortex. Hyphae growing outwards and downwards can also be seen. The passage downwards of gonidia from the region of the first hyphae of the primary cortex are sketched in. The cells of the older more mature gonidial layer, still covered by the primary cortex, are shown on the right. The hyphae of the last group of gonidia on the right are sending up hyphae to form ultimately the secondary cortex. Below the gonidial layer can be seen medulla and hypothallus. × 200.

Fig. 2. Margin of protothallus showing limiting membranes of matrix, primary cortex, undifferentiated median hyphae and primary hypothallus. × 900.

Fig. 3. Group of two algae which have just entered the hyphae of the primary cortex. × 900.

Fig. 4. Larger group of algae now below the primary cortex, the surrounding hyphae having been stimulated to increased activity by the intruding algae. × 900.

Plate II

Fig. 1. A group of intrusive algae now some distance below the surface. At their proximal end (on the right) are seen the swollen hyphae, rich in cytoplasm (Nienburg's "Schiebehyphen"). At the distal side is seen the characteristic gap in the hyphae. × 900.

Fig. 2. Lower side of the protothallus showing hyphae of the primary hypothallus pushing their way into the substratum. On the left is seen a single algal cell with the characteristic hyphal cells rich in cytoplasm at its proximal end. Outside the hypothallial hyphae are seen two dark cells probably representing a fungal spore. × 900.

Fig. 3. Young gonidial group still covered by the primary cortex. The group of algae was probably taken in at the protothallus. × 900.

Fig. 4. Primary cortex and group of gonidia spreading laterally by division of the algae. × 900.

Fig. 5. Hyphae from among the gonidial layer growing up into and piercing the hyphae of the primary cortex, and themselves preparing to form the secondary cortex.

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NOTES ON ENTOMOGENOUS FUNGI

By T. PETCH

(With 4 Text-figures)

1. *Beauveria Peteloti* Vincens

Beauveria Peteloti Vincens was described by Vincens in *Bull. Soc. Bot. France*, Sér. 4, xv (1915), 132–144, from three collections from Brazil, one on the wasp, *Polybia chrysothorax*, another on the wasp, *Polystes canadensis*, and the third on bees, the fungus being so different in appearance in the three cases, that, as remarked by Vincens, one would consider them three different species, were it not that a study of their fructifications showed them to be the same. The following account is based on Vincens' descriptions and figures.

In the specimen on *Polybia*, the insect is attached to a leaf by thick brown strands of mycelium. From the insect arise numerous slender clavae, 2 to 10 mm. long, 0·2 to 0·5 mm. diameter, sometimes thickened upwards, straight or curved, pulverulent, white at first, becoming light brown and polished, and then resembling *Hirsutella Saussurei*. Vincens found that the clavae bore somewhat irregular phialides, varying from an elongated, slightly swollen base, 2–3 μ diameter, to one scarcely differentiated from a normal hypha. The conidia were oval or elliptic, 3–4 × 1–1·5 μ. He regarded the fungus as a form of *Spicaria*, because he sometimes found three phialides arising from a common basal cell. He remarked that the hymenial layer was less compact towards the base of the clava, where the phialides were borne on short tufts of mycelium.

Vincens' photograph of the specimen on *Polybia* shows a general resemblance to *Hirsutella Saussurei*, but the clavae are too white and fluffy in the upper part for that species. His drawings, however, show a much looser external layer than in that species, which has a closely packed palisade layer of hairs and phialides, quite different from the slightly inflated phialides illustrated by Vincens. Moreover, the phialides of *Hirsutella* bear a thin sterigma clearly differentiated from the swollen base, whereas those figured have no such sterigmata.

The second specimen, on *Polystes*, also has clavae arising from the thorax, but these are white, fluffy, and often branched above. The abdomen, however, bears small white cushions, arising from the sutures and forming bands across it, just as commonly occurs on beetles attacked by *Beauveria densa*. These cushions contained conidiophores similar to those borne on the tufts at the base of the clavae on the specimen on *Polybia*, but in addition Vincens found a few zigzag sterigmata which he considered similar to those of a *Beauveria*, and he

figured one arising from a phialide borne on the same hypha as other similar phialides, of the same shape as those of the specimen on *Polybia*. Similar sterigmata were found on the clavae on the thorax, but in that situation they did not arise from differentiated phialides, but were continuations of normal hyphae of equal diameter. The conidia of this specimen were the same as those of the specimen on *Polybia*.

Vincens' figures show that his supposed sterigma is not a *Beauveria* sterigma. It is a normal conidiiferous hypha of a *Sporotrichum*, undifferentiated in diameter from the hypha of which it is a continuation, and is quite different from the extremely fine sterigma of *Beauveria*. The sole point of resemblance is that growth in both is sympodial.

In the third collection, on bees, the insect is covered with a mycelium consisting of pale brown filaments. White clavae arise from the sutures of the insect, but these have collapsed, and hide the insect under a white mass of coarse cottony strands. The fertile hyphae of these strands are less regularly flexuose than those of the specimen on *Polystes*, but they are evidently of the same character.

In temperate climates one is apt to think of entomogenous fungi as species which grow from insects buried in the ground or in decaying wood, and that idea is strengthened by the accounts of the larger species of *Cordyceps* found in the tropics. But by far the greater number of entomogenous fungi in the tropics grow on insects attached to living leaves of trees and shrubs at some distance from the ground. Naturally, one would expect those which attack scale insects to occur on living leaves or stems, as the insects themselves occur normally in that situation, but fungi which attack spiders, flies, wasps, ants, cockroaches, etc., are also found, as a rule, on insects attached to the under side of living leaves. In collecting entomogenous fungi, one looks on the ground and examines decaying logs, for the larger *Cordyceps*, and other fungi which grow on insects in such habitats, but to make any representative collection of the species of a given district one must examine the under surfaces of leaves, which is most easily done by turning over, or cutting off, the branches of the jungle undergrowth.

From the beginning of the rainy season, one finds an increasing number of specimens in that situation. Infected insects settle on the under side of the leaves, are fixed to the leaf by the mycelium of the fungus, and die in that position. Subsequently, the fructifications are developed. But the specimens do not remain there indefinitely or until the leaf falls. Like other fungi, they decay, the decay being accelerated by the attacks of mites and insects, and especially by other fungi. Towards the close of the rains, very many of the specimens one finds have been attacked by secondary fungi.

This "superparasitism" is soon realised, if one makes periodic collections, in the same locality, of a well-defined species, such as *Cordyceps dipterigena* B. & Br. At first one gathers the typical specimens

of this species, with the two glabrous perithecial clavae arising from the thorax and the slender conidial clava from the tip of the abdomen. As the rainy season progresses, one meets with specimens which bear the various stages of *Byssostilbe tomentosa*, or *Sporotrichum album*, or other fungi, these being confined to the *Cordyceps* clavae, so that there is little doubt that they are parasitic on the *Cordyceps* and not on the insect. Later, specimens are found on which the *Cordyceps* has been almost obliterated by the secondary fungus, and only a careful examination, and a knowledge gained from previous specimens, will enable one to discover the remains of the *Cordyceps*, sometimes only the strigose brown mat which fastened the insect to the leaf.

Many of these secondary fungi have been recorded in previous papers. *Aegerita Webberi* is the host of several. *Cladosporium* spp. attack almost all entomogenous fungi, but especially *Hypocrella* and *Aschersonia*. Species of *Cephalosporium* are common. *Gibellula* may be so far obliterated by secondary fungi, that it can only be recognised by the remnants of the stalks of the conidiophores.

It may be queried whether it is correct to style these fungi superparasites. *Melanospora parasitica* is undoubtedly parasitic only on fungi, and *Byssostilbe tomentosa* and *Byssostilbe fusca* are probably parasitic on *Cordyceps* and *Torrubiella* respectively. But whether the various species of *Sporotrichum*, *Cephalosporium*, *Cladosporium*, etc., found on entomogenous fungi are restricted to that substratum, or to fungi in general, or are merely common saprophytes, cannot be stated in the light of our present knowledge of tropical fungi.

The foregoing remarks will illustrate the necessity of bearing in mind that entomogenous fungi can serve as hosts for other fungi, especially Hyphomycetes, and that it cannot be concluded that all the fungi found on an insect at the same time are stages of the same fungus, nor that the most obvious fungus on an insect is the one which killed it. Secondary fungi are to be expected on specimens gathered during prolonged wet weather.

With *Beauveria Peteloti* Vincens, there is little room for doubt that the conidiophores figured by Vincens are not those of a *Beauveria*, but of a *Sporotrichum*, which is growing on the clavae of *Hirsutella Saussurei*. According to Vincens' figures, the *Sporotrichum* is very near *S. album* Petch, but has smaller conidia. In the specimen on *Polybia* it is growing on the clavae only. In the specimen on *Polystes* it is growing on the clavae and on the body of the insect, the latter being permeated by the mycelium of the *Hirsutella*. In the third collection, on bees, it has overwhelmed all the clavae, and united them in a tangled mass. The three collections illustrate progressive stages of "mouldiness."

2. Sporotrichum

Sporotrichum album Petch, parasitic on *Cordyceps dipterigena* B. & Br., was described in *Trans. Brit. Myc. Soc.* xi (1926), 262. In culture on Quaker Oat agar, it gave a very scanty growth and coloured the agar chocolate-brown, but did not produce conidiophores. A figure of the conidiophore is given below (Fig. 1).

Fig. 1. *a*, *Sporotrichum album*; *b*, *Sp. isarioides*, conidiophore and conidia. × 1000.

Another *Sporotrichum* has been found on *Cordyceps dipterigena* at Nuwara Eliya, Ceylon. In addition to a covering of short erect conidiophores over the *Cordyceps* or the insect, it commonly produces "*Isaria*" forms, as many as twenty together in a single tuft. Sometimes the only indication of the presence of the *Cordyceps* is the brown strigose mat of mycelium which fastens the insect to the leaf, the clavae of the *Sporotrichum* then arising directly from the body of the insect. In culture on Quaker Oat agar it developed a continuous even pulverulent growth over the whole slant, with numerous short, erect, rather loose, cylindrical processes. It may be known as *Sporotrichum isarioides*.

Sporotrichum isarioides Petch, n.sp. White; forming a sparse pile of short erect conidiophores over the *Cordyceps* or its host insect, and also producing white cylindrical clavae, singly or in tufts. Clavae up to 1 cm. long, 0·6 mm. diameter, simple or branched, variously curved, peripherally somewhat floccose with flexuose interlaced conidiophores. Conidiophores branched, ends of the branches rough with the points of attachment of the conidia. Conidia oblong-oval, ends obtuse or subacute, hyaline, 3–4 × 1·5 μ.

On *Cordyceps dipterigena* on *Mydaea* (a fly), Nuwara Eliya, Ceylon, 1927–28.

3. Beauveria

Beauveria laxa Petch, n.sp. Forming white or cream-coloured pulverulent masses. Mycelium stout, up to 3 μ diameter. Prophialides lateral on the hyphae, or terminal on short lateral branches, often in whorls, oval, 4 × 2–3 μ, or globose, 3 μ diameter. Phialides numerous on each prophialide, flask-shaped or globose, with a conical or cylindric neck, 4–6 × 2–3 μ. Conidia hyaline, angularly globose, 1·5 μ diameter, or angularly oval, 1·5–2 × 1–1·5 μ, crowded on the sterigma and distorted by mutual pressure.

On larvae of a Lepidopteron, Kirimettia, Ceylon, January, 1927; also on *Tortrix* larvae, lepidopterous cocoons, tineid cases, and spiders, Nuwara Eliya, Ceylon, 1927–28.

This species differs from *Beauveria Bassiana* in its more regularly globose prophialides and its irregular conidia. The conidia are situated close together on the sterigma, which is not easily discerned, as it, with its attached spores, generally separates from the phialide as a whole, simulating a chain of conidia. In other species of *Beauveria*, the conidia are more widely separated and many of them fall off individually, so that for both reasons the sterigma is more easily seen. The prophialides usually stain more deeply with iodine than the conidia, and hence are visible as globose bodies in the middle of the spore cluster, which is more compact than in other species of *Beauveria*.

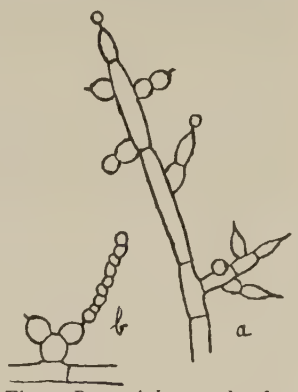

Fig. 2. *Beauveria laxa*. *a*, developing phialides; *b*, two phialides and a chain of conidia. × 1000.

When developed from cocoons embedded in moss, or under bark, the fungus penetrates the overlying substance in coarse strands and forms pulverulent cushions on the exterior. When dissected out, it has then the appearance of an *Isaria* with a subglobose head.

In culture on Quaker Oat agar slants, the fungus fills the tube with a white, loose, fluffy mass of mycelium and spreads over the glass in strands. Conidia are produced somewhat tardily, and in small scattered masses over the mycelium, not in a uniform stratum as in *Beauveria Bassiana*. In culture, the phialides first formed, may, as in other species of *Beauveria*, occur in a different manner and may differ in shape, *i.e.* they may be subcylindric, lateral on the hypha (lacking a prophialide), with a whorl of phialides below, or elongated flask-shaped, up to 10 μ high, 1·5–2·5 μ diameter at the base, lateral on the hypha, singly or in whorls.

Quaker Oat agar is not coloured by the growth of the fungus on it. On Dox agar, the growth is the same, and the agar is not coloured.

In old cultures, white globose parenchymatous bodies, sometimes in clusters up to 4 mm. in diameter, occur in the agar, and yellow conoid perithecioid bodies, up to 0·2 mm. diameter and 0·3 mm. high, in clusters on the glass. No spores have been found in these.

Beauveria Bassiana has been collected recently in Ceylon on caterpillars, beetles, *Astycus* sp., a pentatomid (*Cyclopeltella siccifolia*), tineid cases, a millipede, and a nest of centipedes. Specimens have been received from Dr C. F. Beeson, Dehra Dun, on the larva of *Haplocerambyx spinicornis* and on a longicorn larva.

Beauveria densa has been collected recently in Ceylon on a leafhopper, on various beetles, and on lepidopterous cocoons.

From Mr E. E. Green, I have received specimens of *Beauveria Bassiana*, on a Jassid, Camberley, Surrey, November, 1926, and on

Lecanium (? *persicae*) on *Cornus sanguinea*, Cheddar, Somerset, August, 1926. In the former, the fungus forms pale yellow, or ochraceous, rather loose pulvinate masses underneath and at the sides of the insect. On the *Lecanium*, the mycelium is abundant and forms a rather dense stroma, with a patch of conidia at one end.

It may be noted that, on young or poorly developed stromata of *Beauveria*, the phialides may bear only a single conidium on a short slender sterigma. Sometimes, when the majority have only a single conidium, a few may be found which bear two conidia on a short once-branched sterigma. Several specimens have been collected in this condition in Ceylon, and have been proved to be *Beauveria* by cultivation on agar. Often, the typical *Beauveria* sterigma is obtained if the specimen is merely left in a glass tube.

Except for a record of *Beauveria Bassiana* (as *Sporotrichum globuliferum* Speg.) on the flesh of dead birds recently received from America, by Miss A. L. Smith in *Trans. Brit. Myc. Soc.* 1 (1897), 70, no mention of *Beauveria* has appeared in British lists. There are, however, specimens in British herbaria.

In Herb. Kew., in the cover of *Isaria farinosa*, there is an unnamed specimen of a fungus on a Coccinellid, marked "Bishop's Wood." This is *Beauveria Bassiana*.

Also in Herb. Kew., in the cover of *Isaria crassa*, there is a specimen marked "*Isaria* E.C. Herb. Mycol. M.C. Cooke," on a pupa buried in vegetable debris. This again is *Beauveria Bassiana*. This may be the specimen referred to by Cooke in *Vegetable Wasps and Plant Worms*, p. 181, where he stated that "The only occasion on which we have met with this species [*Isaria crassa*] in Britain occurred on a much larger pupa than those on which we find *Isaria farinosa*."

In Herb. British Museum, in the cover of *Isaria arachnophila*, there is a specimen marked "*Isaria arachnifera*? Kent, Sept. 1837. Ch. Forest, C.B.," *ex* Herb. Bloxam. The insect is hidden in straw, and cannot be determined without dismembering the specimen. It bears several erect clavae, which resemble *Isaria farinosa*, but on microscopical examination it proved to be *Beauveria densa*.

I have recently collected in England, *Beauveria Bassiana* on pupae at Black Hills, North Wootton, March 23rd, 1930, and West Briggs, September 2nd, 1930, and on spiders at North Wootton Heath, May 14th, 1930, Holt House Wood, August 12th, 1930, and Bawsey, September 3rd, 1930; and *Beauveria densa* on a weevil and on a spider, Black Hills, March 30th, 1930, and on a beetle, Holt House Wood, April 3rd, 1930. All these localities are in Norfolk. Miss Brett collected *Beauveria Bassiana* on a Coccinellid near Barton Mills (Suffolk), on August 21st, 1930.

4. Rhinotrichum album Petch

This species was described in *Trans. Brit. Myc. Soc.* xi (1926), 258, from a specimen on *Lecanium*, on which it formed a loose white pile consisting of rigid erect conidiophores. Further collections of this species, and their culture on Quaker Oat agar, have shown that it is the same as *Gonatorrhodiella coccorum* Petch, *Trans. Brit. Myc. Soc.* x (1925), 181, which was originally obtained in culture from *Lecanium viride*, in company with *Cephalosporium Lecanii*. It has now been collected in Ceylon on *Lecanium*, *Aleyrodes*, aphides, and leaf-hoppers.

5. Volutella epicoccum Petch

In *Trans. Brit. Myc. Soc.* xii (1927), 44–52, I described *Peziotrichum Lachnella* Sacc., *Ophionectria coccorum* Petch, and *Volutella epicoccum* Petch, three fungi on scale insects, having similar circular brown byssoid stromata, from which arise erect fascicles of bristles. *Peziotrichum Lachnella* is a sterile stroma, which, however, bears globose pseudoconidia on the repent hyphae of the stroma. These pseudoconidia had been found on one occasion on the stromata of *Ophionectria coccorum*, but up to the time the above paper was written they had not been observed on the stromata of *Volutella epicoccum*.

The last-named fungus occurs in abundance on one tree of *Cinnamomum ovalifolium* at Hakgala, Ceylon. On revisiting this tree on May 7th, 1927, fallen leaves bearing effete stromata of the *Volutella* were collected, and the repent hyphae of these stromata were found to bear the globose pseudoconidia characteristic of *Peziotrichum*.

6. Hypocrella Schizostachyi P. Henn.

Hennings described the colour of this species as "cinereo-testaceus." As previously stated (*Ann. R.B.G. Peradeniya*, vii (1921), 223), the cotype specimens submitted to me were reddish purple, and they were figured that colour on Pl. II, fig. 7 (*op. cit.*). Recent, younger, specimens, from Sumatra, on *Lecanium bambusicola* Green (Mss.), kindly furnished by Mr E. E. Green, are ochraceous, or reddish ochraceous, sometimes with an ashy bloom, and blackening irregularly, the tubercles dotted with red-brown ostiola.

7. Isaria abietina v. Höhnel

Isaria abietina was described by von Höhnel in *Fragmente zur Mykologie*, No. 277 (*Sitzungsber. d. K. Akad. d. Wissenschaft. in Wien, Math. Nat. Kl.* cxviii (1909), 416). The specimen had been collected by Ouwens in Java, and was said to grow on a "Baumwanze."

The synnemata were awl-shaped, about 3 mm. high, 300 μ diameter below, 55 μ diameter above, scattered or in rows, sometimes fasciculate. In the lower half they bore short, cylindric, obtuse processes,

perpendicular to the clava, up to 160 μ long, 55 μ diameter. The lengths of the processes diminished from the base of the clava upwards, and von Höhnel stated that, when magnified, the whole fungus looked like a young fir tree—whence the specific name. The lateral processes, like the main clava, were composed of parallel hyphae, the ends of which formed, on the clava and the processes, a hymenium consisting of parallel, obtuse hyphae, perpendicular to the surface. The conidia were very small, globose, situated in clusters on the tips of the hyphae.

von Höhnel's specimen was one of those which had been collected some time before his visit to Java and handed over to him during his stay there. Several of these had been preserved in alcohol and then dried. As regards *Isaria abietina*, von Höhnel stated that the arrangement of the spores was obscure, and probably the description would require amendment.

From Mr T. Bainbrigge Fletcher, Imperial Entomologist, Pusa, India, I have received specimens which, macroscopically, agree exactly with von Höhnel's figures of *Isaria abietina*. These are on *Pyrilla pusana*, a hopper which attacks sugar cane. The clavae are up to 3 mm. high, 120 μ diameter below, tapering upwards, lavender in colour, and arise in clusters or rows from the sutures of the insect, united by mycelium at their bases but without any general covering of mycelium over the insect. The main clava is composed of parallel hyphae, and bears, in the lower half, lateral, subcylindric processes, up to 120 μ long and 40 μ diameter, perpendicular to the clava and composed of parallel hyphae with clavate tips which curve outwards but do not separate. In all these features the fungus agrees with *Isaria abietina*.

The upper part of the clava, however, bears *Hirsutella* conidiophores. These are up to 26 μ high, with an oval base, 8–10 × 5 μ, abruptly attenuated into an elongated sterigma, up to 16 μ long, 1·5 μ diameter below, tapering upwards. The cluster of four spores is lemon-shaped or oval, 5–6 × 3 μ. The separate conidia are oval or subcymbiform, ends usually obtuse, 4–6 × 2–2·5 μ. These conidiophores have not been found on the lateral processes.

The supposed conidia observed by von Höhnel may have been intrusive, or they may have been artefacts due to preservation in alcohol. The fungus is a *Hirsutella*, and must be known as *Hirsutella abietina*, comb. nov.

8. Naemosphaerella

Naemosphaerella epimyces Petch, n.sp. Pycnidia black, not carbonaceous, globose, 0·25 mm. diameter, superficial or partly immersed, with a long conical beak, up to 1 mm. high, 120 μ diameter below, 50 μ diameter above; base of the pycnidium clothed with a thin layer

of rusty tomentum which also covers, wholly or in part, the host stroma; mycelium brownish yellow, thick-walled, irregular, 4 μ diameter; spores blackish brown, cuboid, 11–14 × 9–11 μ, or globose, 9–11 μ, thick-walled, on stout pedicels from the pycnidium wall; chains of spores not seen.

On the stromata of *Aegerita Webberi* Fawcett on *Psychotria Thwaitesii*, Nuwara Eliya, Ceylon, June 26th, 1927; *ditto* on *Calophyllum* sp., Nuwara Eliya, March 11th, 1928.

9. Oospora

Oospora insectorum Petch, n.sp. White, covering the insect with a loose weft; hyphae slender, 1·25–1·75 μ diameter; conidiophores lateral and terminal, the former perpendicular to the hypha, but becoming oblique towards its extremity, so that the terminal group resembles a compound conidiophore with distant branches; conidiophores cylindric, attenuated above, 12–28 μ high, 1–1·5 μ diameter below, continuous or one-septate, usually simple, sometimes with a lateral branch; conidia in a terminal chain, narrow-oval or oblong-oval, hyaline, continuous, ends obtuse, 3–5 × 0·75–1 μ.

On a spider, Nuwara Eliya, Ceylon, September 11th, 1927; on pupae, Nuwara Eliya, October 10th, 1927, August 9th, 1928; on ? *Aleyrodes*, Nuwara Eliya, November 13th, 1927. In one specimen, on a pupa, the conidiophores form small, subglobose tufts on and round the cocoon.

On Quaker Oat agar, the growth is white and woolly, covering the whole slant and spreading over the glass. Conidia are tardily produced, and form best on the glass. When old, the stroma becomes pinkish in the centre. The agar is coloured pale ochraceous or yellow-brown.

Oospora subfasciculata Petch, n.sp. Mycelium white, scanty, closely investing the host, sometimes arising in short columnar tufts; conidiophores simple, elongated conoid, 16–24 μ high, 1·5 μ diameter at the base; conidia in a terminal chain, hyaline, continuous, narrow-oval, ends acute, 2–3 × 1·1–5 μ.

On a millipede, Nuwara Eliya, Ceylon, June 12th, 1927; on a pupa, Nuwara Eliya, August 15th, 1928.

Fig. 3. *Oospora insectorum*. *a*, lateral conidiophore; *b*, terminal conidiophores. × 1000.

On Quaker Oat agar, the growth is white, strigose with numerous erect fascicles or columns, 2–3 mm. high; the agar is not coloured. The growth on Dox agar was similar, but no conidia were produced on this medium.

Of the species of *Oospora* previously recorded as parasitic on insects, *Oospora ovorum* Trabut, parasitic on the eggs of *Acridium peregrinum*,

was described as having globose spores, 0·7 μ diameter; *Oospora Aphidis* Cke. & Massee is a mixture of an *Oidium* and an *Entomophthora* (*Trans. Brit. Myc. Soc.* xi (1926), 265); *Oospora necans* Sacc. & Trott., on *Pemphigus bursarius* in galls on *Populus nigra*, apparently resembles *Oospora insectorum*, but differs in its conidiophore.

10. Tilachlidium

A species of this genus was collected at Nuwara Eliya, Ceylon, in January, 1928, on larvae of a microlepidopteron on a living leaf, each larva being covered by a web, the clavae of the fungus emerging through the web.

Tilachlidium larvarum Petch, n.sp. Mycelium white, covering the insect. Clavae numerous, white, up to 1 mm. high, 0·05 mm. diameter, cylindric, composed of parallel agglutinated hyphae, bearing conidiophores laterally, perpendicular to the clava, moderately crowded, but not forming a palisade layer. Conidiophores stout, conical or slightly flask-shaped, attenuated gradually upwards, 14–22 μ high, 2 μ diameter at the base, simple. Conidia persistent in mucilaginous heads, up to 14 μ diameter, on each conidiophore. Conidia narrow-oval, ends rounded, hyaline, 4–6 × 2–2·5 μ.

On larvae of a micro-lepidopteron, Nuwara Eliya, Ceylon.

This species is similar to *Tilachlidium subulatum* A. L. Smith. On this view *Tilachlidium* is a *Stilbum* which bears *Cephalosporium* conidiophores laterally.

11. Acremonium griseum Petch

This species was described in *Trans. Brit. Myc. Soc.* xi (1926), 262, from a specimen on a spider, collected at Hakgala, Ceylon, in March, 1922. During 1926–28, it was found in abundance at Nuwara Eliya, Ceylon, usually on spiders, but also on a cocoon (Lepidopteron) and on a fly (*Mydaea* sp.).

The fungus covers the body of the insect with a rather loose pulverulent stroma, and spreads out along the legs and over the leaf to which the insect is fixed. The stroma is usually nodular with small tufts of conidiophores, or protuberances of hyphae, and these are generally a well-marked feature along the legs of the insect. When old, the stroma becomes more floccose. Its colour may be yellowish-grey or lavender, fading with age to ashy or white.

The species was originally described as having simple conidiophores. These, elongated conoid and up to 16 μ high, occur on the looser parts of the stroma. The tufts, however, consist of loosely interwoven, more or less erect hyphae which bend outwards and branch repeatedly, the ultimate branches usually terminating in a single phialide, with two opposite phialides about 16 μ below the apex

(Fig. 4). Thus, on viewing a mounted tuft or protuberance, one sees a rather loose central core, fringed by interlacing pencils of conidiophores.

The protuberances may be so strongly developed that they may be classed as clavae. One specimen, on a spider, bears eighteen small erect clavae, up to 3 mm. high, bifurcating above and covered with minute nodular tufts. Another specimen, on *Mydaea*, bears numerous thin clavae, pale ochraceous to white, forming a large spreading tuft; these clavae are simple or branched, up to 1 cm. long, 0·1–0·2 mm. diameter, nodular with tufts of conidiophores. This latter specimen was thought to be a different species, but in culture it proved to be *Acremonium griseum*. It is an *Isaria* form of that species.

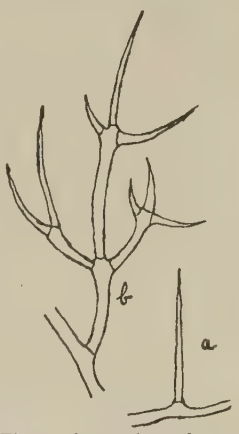

Fig. 4. *Acremonium griseum*. *a*, simple conidiophore; *b*, pencil of conidiophores from a tuft. × 1000.

In culture on Quaker Oat agar, the fungus forms a thin pulverulent stroma, which ultimately covers the whole slant. The stroma is at first white, then yellowish green or emerald-green with a broad white margin. A few tufts are formed in the centre of the stroma, but no elongated clavae have been obtained in culture. The agar is coloured pale reddish purple.

On Dox agar, growth was poor—a small, loose, grey tuft with a broad, thin, transparent, feathery margin. No conidia were produced on this medium, which becomes coloured deep purple.

In the type specimen of *Acremonium griseum*, the fungus occurred on a spider in company with *Gibellula* (not *Hirsutella*, as previously suggested), and it was thought that the *Acremonium* was parasitic on the *Gibellula*. Several other specimens have been collected in which this fungus occurs with *Gibellula*, on a spider, and others with *Beauveria* and *Spicaria* respectively, on cocoons and tineid cases. In the majority, however, the *Acremonium* occurs alone, and it is probable that the former specimens are merely instances of the occurrence of two entomogenous fungi simultaneously on the same insect.

The conidia are narrow-oval or sub-fusoid, hyaline, continuous, 3–5 × 1–1·5 μ, ends acute or obtuse, or one end subacute. Sometimes, especially in culture, they persist in short chains of three or four.

12. Botrytis necans Massee

Botrytis necans was described by Massee in *Kew Bulletin* (1914), p. 159. The fungus occurred at Singapore and in the Federated Malay States, on the larvae of *Brachartona catoxantha*, a pest of coconuts, killing them in large numbers. There is a type specimen in the Kew Herbarium, which I had apparently previously overlooked.

Massee described the conidia as very numerous, acrogenous, solitary, globose, 4 μ diameter. They are globose, 1·5–2 μ diameter, or broadly oval, 1·5 × 2 μ, in a typical *Beauveria* head. The fungus is *Beauveria Bassiana.*

13. Botrytis Eriophyes Massee

Botrytis Eriophyes was found on the mite *Eriophyes ribis* in "big bud" of black currant, and was described by Massee in Taylor, *Journ. Econ. Biol.* IV (1909), 5. It was said to form small white patches of repent, septate hyphae, from which arose erect conidiophores with subverticillate branches and branchlets. The branchlets (phialides) were slender, with a subacute apex, and bore conidia near the apex. The conidia were cylindric, hyaline, continuous, straight, 5–8 × 1·5–2 μ. In Saccardo, *Sylloge Fungorum*, XXII (1913), 1299, it was transferred to the genus *Verticillium*, as *Verticillium Eriophytis* (Massee) Sacc. & Trott.

The type in the Kew Herbarium consists of a single bud scale which bears a minute white patch of mycelium, covering the insect, at the base. This bears simple conidiophores, up to 20 μ high, 2 μ diameter below, attenuated upwards, arising singly or in groups from the mycelium. Each conidiophore bears a globose head, 4–8 μ diameter, of conidia united by mucilage. The conidia are cylindric, or narrow-oval and inequilateral, with rounded ends, 4–6 × 1·5–2·5 μ.

The fungus is a *Cephalosporium*, or, assuming that Massee saw branched conidiophores, an *Acrostalagmus*. It must stand as *Cephalosporium* (*Acrostalagmus*) *Eriophytis* (Massee), comb. nov. The small-scale figures in Taylor, *loc. cit.*, are good representations of a *Cephalosporium*, but in the large-scale figures the conidial heads are lacking, having probably been lost in manipulation.

14. Isaria Cicadae Miq.

Isaria Cicadae was described by Miquel in *Bull. d. Sci. Phys. et Natur. en Néerlande*, I (1838), 85–86, Pl. I, from a specimen from Brazil. It was recorded by Cooke for Australia in the *Handbook of Australian Fungi*. The specimen on which this record was based is now in the Kew Herbarium, and is labelled "Fungi growing on Cicadae (Locust), Port Phillip, C. French Jr., 6. 6. 90." The fungus does not bear any resemblance to the original figures of *Isaria Cicadae*, but forms small white or cream-coloured cushions. Examination shows that this Australian specimen is *Beauveria Bassiana.*

An *Isaria* on Cicada from New Zealand was described by Berkeley as *Cordyceps Sinclairii*. The same fungus occurs in the hill districts of Ceylon. It is a large species, very variable in form, usually divided into two or more stems from the base and branched into coarse lobes above, but sometimes forming a cluster of stout stalks from the head

of the insect, each with a compact subglobose head. It has large conidia, up to 8 μ long.

When von Höhnel visited Java, he was given an *Isaria* on a Cicada, which had been preserved for a long time in alcohol. This he described as *Isaria amorpha*. His description fits *Isaria Sinclairii*, though he gave the spores as 3–4 μ long. Under the conditions of preservation, however, it is probable that most of the conidia would be lost, and it seems certain that *Isaria amorpha* is *Isaria Sinclairii*.

Long-spored species of *Isaria* on Cicadae have been described as *Isaria Harioti* Arnaud, from Madagascar, *Isaria arbuscula* Hariot, from Mexico, and *Isaria Cosmopsaltriae* Yasuda, from Japan. From the figures and descriptions of these species, it is probable, as previously suggested by Lloyd (*Mycol. Notes*, No. 56, p. 806), that they are all *Isaria Sinclairii*.

The original specimen of *Isaria Cicadae* was in bad condition, but Miquel soaked it out in hot water and made the best he could of it. Thus his figure shows only the skeleton of the fungus, and it is what *Isaria Sinclairii* would be expected to look like after similar treatment. But until *Isaria Cicadae* has been re-found in Brazil, the question of its identity with the other species on Cicada must remain in abeyance.

15. Metarrhizium

Metarrhizium Anisopliae (Metsch.) Sor. is the fungus which causes the disease of insects known as the Green Muscardine, in both temperate and tropical countries. It was first recorded by Metschnikoff in 1879, as *Entomophthora Anisopliae*, on the cockchafer of wheat, *Anisoplia austriaca*, in Russia, and attempts were made to control the insect by means of the fungus. In the same year, Sorokin instituted for it a new genus, *Metarrhizium*. In 1880, Metschnikoff published another paper on the subject, and gave the fungus a new name, *Isaria destructor*. Subsequently it was found in France, and in 1893 Delacroix recorded it as *Oospora destructor* (Metsch.) Delacr. Hart found it on froghoppers in Trinidad, and twenty years later specimens from that country were re-described as *Septocylindrium suspectum* by Massee (*Kew Bulletin*, 1910, p. 4). There is an extensive literature relating to the attempts to control the froghopper of sugar-cane by means of this fungus in Trinidad (for bibliographies, see Rorer, J. B., "The Green Muscardine of froghoppers," *Proc. Agric. Soc. Trinidad and Tobago*, x, 467–482, *Society Paper*, No. 442 (1910), and Williams, C. B., "Report on the froghopper blight of sugar-cane in Trinidad," *Mem. Dept. Agric. Trinidad and Tobago*, No. 1 (1921)).

Pettit, who cultivated this, or a similar, fungus, stated that "the branched mycelium bears heads which are branched like *Penicillium* and bear long chains of conidia, cylindrical in form and rounded at the ends" "Studies in artificial cultures of entomogenous fungi,"

Cornell Univ. Agric. Expt. Sta. Bull. 97 (1895)). Vuillemin, in 1904 (*Bull. Soc. Myc. France*, xx, 214–221), transferred it to that genus as *Penicillium Anisopliae* (Metsch.) Vuill. This change has not met with universal acceptance. von Höhnel (*Fragmente zur Mykologie*, No. 269), though he adopted Vuillemin's transfer, stated that the branching of the conidiophore was not typically penicillioid. Rorer (*loc. cit.*) wrote: "It seems quite certain that the fungus is not an *Oospora* or a *Penicillium*, and probably not an *Isaria*, though in some culture media it takes on a more or less tree-like growth, characteristic of that genus. As it cannot be left in the genus *Entomophthora*, where it was first placed, perhaps it would be better to call it *Metarrhizium Anisopliae* (Metsch.) Sor., and consider it the type of the genus, which was created specially for this fungus and its characteristics are not those of any other described genus."

My opinion coincides with Rorer's. Though *Metarrhizium Anisopliae* may have resemblances to *Oospora* and to *Penicillium*, it is not characteristic of either, and the genus forms a convenient centre for a group of species which are decidedly abnormal in either of the other two.

Penicillium cicadinum v. H., described by von Höhnel from a specimen on a cicada from Java, is a "Green Muscardine," admittedly a *Metarrhizium*, and should stand as *Metarrhizium cicadinum* (v. H.). *Penicillium Briardi* Vuill. (*Isaria truncata* Briard *non* Pers., *Coremium Briardi* Sacc. & D. Sacc.) is, by Vuillemin's statement, an Isarioid *Metarrhizium*, and should stand as *Metarrhizium truncatum* (Briard). *Monilia penicillioides* Delacr., transferred to *Penicillium* by Picard, is, from Delacroix's figures and description, apparently not a *Metarrhizium*. *Penicillium Fieberi* Corda is again not a *Metarrhizium*, judging from Corda's figures and description; as books of reference sometimes omit the name of the host insect of this species, it may be noted that Corda stated that it grew on *Pentatoma prasina*.

From von Höhnel's account, it appears that he described his "Green Muscardine" on a cicada as a new species, because, owing to the differences in spore dimensions recorded for *Metarrhizium Anisopliae* by different mycologists, and to the fact that it had been recorded as occurring on so many different hosts, it was probable that the name covered several different, though similar, forms.

I have not been able to consult the papers on *Metarrhizium* by Sorokin and Metschnikoff respectively. Thaxter (*Mem. Boston Soc. Nat. Hist.* iv (1888), 190) stated that the [original] measurements of the spores of *Metarrhizium Anisopliae* were $4{\cdot}8 \times 1{\cdot}6\,\mu$, citing Metschnikoff in *Zeitschr. d. Kaiserl. Landwirth Gesell. f. Neurussland, Odessa* (1879), pp. 21–50, with plate.

Delacroix, who examined *Metarrhizium Anisopliae* found on the larva of *Melolontha* sp. in France, stated that the spores were cylindric,

rounded at the ends, 7–15 × 2·5–3·5 μ (*Bull. Soc. Myc. France*, IX (1893), 260–264). But Pettit (*loc. cit.*), who worked with a culture of *Isaria destructor* from France, supplied by Giard, found the spores cylindric with rounded ends, 6–7 × 3 μ, while in a form which he called var. *americana*, found on the larvae of *Agrotis mancus* near Ithaca, N.Y., they were 5–7 × 3 μ. Rorer (*loc. cit.*) found the spores of the "Green Muscardine" on froghoppers in Trinidad to be cylindric, rounded at the ends, 6–9 × 2–3 μ. Speare (Bull. 12, *Path. and Phys. Series*, *Expt. Sta. Hawaii Sugar Planters' Association*), recorded that the spores of *Metarrhizium Anisopliae* on the beetle, *Rhabdocnemis obscura*, measured 5–7·5 × 2·3–3·7 μ, and stated that although they had the same general appearance they varied somewhat in shape; he figured them as cylindric, or narrow-oval, attenuated towards one end, rather more irregular than in my specimens. Glaser (*Ann. Entom. Soc. Amer.* XIX (1926), 180–192), gave the spores of this fungus on silkworms as oblong, 5–7 × 3 μ.

Friederichs, who studied the Rhinoceros beetle of coconuts in Samoa and elsewhere, and visited several tropical countries in the course of his investigations, has dealt with this fungus at considerable length ("Studien über Nashornkafer als Schädlinge der Kokospalme," *Mon. zur angew. Entomologie*, No. 4; "Ueber die Pleophagie...Metarrhizium," *Centralb. f. Bakt.* Abt. 2, L (1920), 335–356).

Friederichs described the spores as cylindric, or elongated oval, varying in length from 6 to 14 μ, and in breadth from 2·5 to 3·3 μ. On the larvae of *Oryctes rhinoceros* in Samoa and the Philippines they were 9–14 μ long, and the same on the larva of another beetle in the Philippines, but on a cockchafer larva in the Philippines and on *Oryctes* in Madagascar, they were 6–8 μ long. On *Stenodontes insularis* Fairm., in Apia, the spores were 4–5 × 2 μ.

Friederichs recognised the existence of two forms of *Metarrhizium Anisopliae*, a short-spored form with spores 6–8 μ long, and a long-spored form with spores 9–14 μ long. He found the former in his strains from Madagascar, Hawaii, Southern France and Switzerland, the latter in Samoa, and both forms in the Philippines.

von Höhnel gave the spores of *Metarrhizium cicadinum* as oblong-ellipsoid, almost cylindric, 5–6 × 1·5–2 μ, rarely 7 μ long. Although his suggestion that the name *Metarrhizium Anisopliae* has been applied to more than one species is probably correct, it is evident that his measurements do not differ sufficiently from those of the common form, or from Metschnikoff's, to warrant the separation of the form on a cicada as a different species.

Obviously, the long-spored and the short-spored forms might be separated as subspecies or varieties, were it not for the measurements recorded by Delacroix, who apparently found spores covering practically the whole range in one strain.

The following are the dimensions of the spores of specimens collected in Ceylon and attributed to *Metarrhizium Anisopliae*:

On an earwig, Hakgala (5600 ft.); narrow-oval or cylindric, ends rounded, 5–7 × 2–2·5 μ.
On an earwig, Nuwara Eliya (6200 ft.); cylindric, ends rounded, 5–7 × 2 μ.
On a cricket, Hakgala; chiefly narrow-oval, 5–6·5 × 2·5–3·5 μ.
On a black ant, Peradeniya (1600 ft.); narrow-oval or cylindric, ends rounded, 5–7·5 × 2–3 μ.
On Red Weevil (*Rhyncophorus ferrugineus*), Peradeniya; narrow-oval or cylindric, ends rounded, 5–6·5 × 2·5–3 μ.
On larvae of firefly (*Lamprophorus*), Peradeniya; chiefly narrow-oval, 5–6·5 × 2·5–3 μ.
On larva of firefly (*Lamprophorus*), Peradeniya; chiefly cylindric, 5–7·5 × 2–3 μ.
On larva of firefly (*Lamprophorus*), Peradeniya; narrow-oval or cylindric, 5–7 × 2–2·5 μ.
On larva of firefly (*Lamprophorus*), Peradeniya; narrow-oval or cylindric, 5–7 × 2·5–3 μ.
On larva of firefly (*Lamprophorus*), Peradeniya; chiefly cylindric, 5–8 × 2·5–3 μ.
On full-grown larva of *Oryctes rhinoceros*, Peradeniya; cylindric, 10–14 × 3–4 μ, most about 12 μ.
On small larvae of *Oryctes rhinoceros*, Peradeniya; cylindric, 10–12 × 3–4 μ.
On small larvae of *Oryctes rhinoceros*, Peradeniya; cylindric, 10–13 × 3·5–4·5 μ.

The specimens on firefly larvae occurred as accidental infections in the Insectary of the Entomological Laboratory at Peradeniya at intervals over a period of nearly two years. Those on the larvae of the Rhinoceros beetle occurred in the same place, at intervals over a period of eight months, coincident with the beginning of the infection period of the firefly larvae. The long, cylindrical spores on *Oryctes* are sometimes slightly attenuated towards one end, and often gradually contracted from each end towards the centre.

A new species of *Metarrhizium* has been collected in Ceylon, on a leaf-hopper on rice. It differs from *Metarrhizium Anisopliae* in its colour, which is white, in the shape of the stroma, which is convoluted or cerebriform, resembling a flat *Cerebella*, and in the size of the conidia and the apex of the conidiophore. In culture on Quaker Oat agar, it forms circular, white, thick byssoid stromata, about 5 mm. diameter, which become pinkish buff from the centre outwards, and ultimately pinkish buff, pulverulent conidial stromata with a broad white margin. The reverse of the stroma is dark brown. In old cultures the

stromata are fawn-coloured, and the agar brownish yellow to greenish yellow. It may be named *Metarrhizium album.*

Metarrhizium album Petch, n.sp. Stroma cerebriform, covering the insect, white, fuscous internally towards the base; conidiophores arising from a basal stroma of interwoven hyphae, and forming a continuous palisade layer, simple or branched; ultimate branches cylindric, rounded at the apex, 8–10 μ high, 1·75 μ diameter; conidia oval or oblong-oval, hyaline, continuous, 3–4 × 1·75 μ, in chains which persist laterally adherent in columns.

On a leaf-hopper (*Tettigoniella spectra*) on rice, Southern Province, Ceylon, January 1928, *per* Dr J. C. Hutson.

16. Cephalosporium (Acrostalagmus) aphidicola n.sp.

In *Trans. Brit. Myc. Soc.* x (1925), 168, a species of *Cephalosporium* on an aphis, collected at Peradeniya, Ceylon, was referred to *Cephalosporium longisporum* Petch, a species found in Ceylon on *Icerya purchasi.* It differed from the latter in its slightly smaller conidia, and in the conidial heads coalescing into a yellow mass on the body of the insect.

This species has since been found common on aphides at Nuwara Eliya, Ceylon, and it appears to be sufficiently different from *Cephalosporium longisporum* to be regarded as distinct. The yellow colour is not evident unless the conidial heads are massed together, but the conidia are, as a rule, shorter than those of *Cephalosporium longisporum.* It may be known as *Cephalosporium aphidicola* n.sp.

In culture on Quaker Oat agar, the fungus forms a thin, white stroma, with a crystallised appearance due to the heads of conidia. The culture remains white, and the agar is not reddened.

The *Acrostalagmus* conidiophores may attain a height of 90 μ or more in culture, with whorls of lateral branches up to 30 μ long. The conidia in nature are 5–9 μ long, but in culture a few are 10–12 μ long.

Cephalosporium (*Acrostalagmus*) *aphidicola* Petch, n.sp. Mycelium white, sparse; conidiophores simple, up to 36 μ high, 1·5 μ diameter below, elongated conoid, or acrostalagmoid, up to 50 μ high; conidial heads up to 20 μ diameter; conidia oblong-oval, or cylindric, straight or slightly curved, ends obtuse, 5–9 × 1·5–2 μ.

On aphides, Nuwara Eliya, Ceylon, July 3rd, 1927, etc.

Acrostalagmus Aphidum Oud. was described from specimens on "skeletons" of an aphis on *Aristolochia gigas* in the Botanic Garden at Utrecht, presumably in a hothouse. It apparently differs from the present species in having trifurcate conidiophores and larger conidia, 7–14 × 2·5 μ. Nolla (*Journ. Dept. Agric. Porto Rico*, xiii (1929), 59–72), dealing with a species referred by him to *Acrostalagmus Aphidum*, states that its spores have a wider range of length and breadth than is given in the original description.

17. Cephalosporium crassum n.sp.

Dr G. O. Ocfemia has sent me from the Philippines specimens taken on Abaca (*Musa textilis*), of aphids, *Pentalonia nigronervosa* Coq., which are attacked by a fungus. The fungus is evident as coarse white tufts arising from the joints of the legs, and on closer inspection similar tufts are seen on the body. Repent hyphae extend from the tufts, both on the legs and on the body. The conidiophores occur in the tufts, and also scattered along the repent hyphae.

This species differs from the *Cephalosporium* found on aphids in Ceylon in its stout conidiophores and broad conidia. It may be known as *Cephalosporium crassum*.

Cephalosporium crassum Petch, n.sp. Conidiophores clustered in minute, white, pulvinate tufts, up to 0·3 mm. diameter, arising from the joints of the legs or on the body, with scattered conidiophores on repent hyphae round the tufts. Conidiophores simple, occasionally with a lateral branch, up to 50 μ high, stout, the smaller flask-shaped, the larger conoid, up to 4 μ diameter at the base, 1·5 μ diameter at the apex; conidia in a mucilaginous head up to 16 μ diameter; conidia oval or cymbiform, ends obtuse, hyaline, continuous, 8–12 × 3–5 μ. On an aphid, *Pentalonia nigronervosa* Coq., Los Banos, Philippine Islands, January, 1929.

18. Sterigmatocystis ferruginea Cke.

This species was described by Cooke in *Grevillea*, VIII (1879), 95. A further account of it was given in a paper, "Some Remarkable Moulds," *Journ. Quekett Microscopical Club*, II, Ser. 2 (1885), 139, and this was republished in all essential details in *Vegetable Wasps and Plant Worms* (1892), 184. It occurred on the pupa of the Eri Silk Moth (*Attacus ricini*) in Cachar. The type is now in the Kew Herbarium. Thom (*Aspergilli*) states that as it was not certain that the spores were produced in chains, the name should be dropped.

Cooke stated that the greater part of the exterior of the pupa was covered with a bright rust-coloured mould. The type specimen now bears effused, dark rufous brown patches which consist chiefly of a felted mass of conidia and crushed conidiophores. A few conidiophores, which have escaped crushing, stand more or less erect at the margin of a patch.

The stalk of the conidiophore is hyaline, smooth, about 12 μ diameter, and expands above into a globose receptacle, about 50 μ diameter. This receptacle bears close-packed, radial prophialides, which are clavate, 30 μ long, 5 μ diameter below, 12 μ above, facetted obliquely at the apex. Each prophialide bears several phialides, which are ovato-cylindric, or barrel-shaped, 14–18 × 7–9 μ, the apex rounded or truncate. The apex of the phialide is brown and verrucose,

and often bears a short cylindrical sterigma, either central or at one corner. One phialide was seen, which had an old sterigma at one corner and a developing conidium at the other, but phialides with three or four sterigmata, as described by Cooke, were not observed. In some cases, the phialide bears an arrested spore, oval, with its long axis perpendicular to the axis of the phialide; this spore may be cut off by a septum or not.

The conidia are yellow-brown, globose, 6–9 μ diameter, or oval, 9 × 5 μ, coarsely warted or with conical blunt spines up to 1 μ long. I was unable to find any spores in chains. Most of the conidia have germinated, and are bound together in a tangled mass of hyaline hyphae, 1 μ diameter.

The verrucose brown apex of the phialide, the arrested development of some of the conidia, and the large spinose spores on hyaline mycelium, suggested that the spores might be those of a *Sepedonium* which had overrun the *Sterigmatocystis*. I have, however, received *Aspergillus parasiticus* Speare from the United States in an exactly similar condition, most of the conidia having germinated in transit.

Cooke's account of this species is substantially correct, and there does not appear to be any doubt that it is a *Sterigmatocystis*.

Sterigmatocystis fulva (Mont.) Sacc. was described from a specimen on the silkworm, *Bombyx mori*, in France. The stalk of the conidiophore was said to be rough, the head golden then fulvous, and the conidia minute. Cooke's species apparently differs, *inter alia*, in its large conidia.

19. Penicillium brevicaule Sacc.

This species occurs on dead insects, probably as a saprophyte. I have had specimens on lepidopterous larvae in Ceylon, and on a larva of *Calandra glandium* from Dehra Dun, India, and cultures of it, obtained from a dead cotton stainer, *Dysdercus nigrofasciatus*, from Mr C. G. Hansford, Kampala, Uganda.

20. Ophiocordyceps gen. nov.

The majority of the species of *Cordyceps* which have been described have long cylindrical asci, with a hemispherical "solid" apex, the lower edge of which appears abruptly transverse to the ascus. The ascospores are filiform, almost as long as the ascus, in a parallel bundle, multiseptate, and divide, when mature, at each septum, into numerous short, continuous, cylindrical part-spores. These ascospores are all so much alike that they have little diagnostic value.

A few species, however, which have been described as *Cordyceps*, have asci and spores of a different type. The asci, instead of being uniformly cylindrical, are clavate, usually with a gradually thickened apex, and the spores are arranged more or less in two overlapping

bundles. The spores are elongated fusoid, multiseptate, and do not divide into part-spores at the septa. Both the ascus and the ascospore agree with *Ophionectria* or *Podonectria*, not with *Cordyceps*.

Cordyceps Blattae Petch, described and figured in *Trans. Brit. Myc. Soc.* x (1924), 35–6, Pl. I, figs. 8 and 14, belongs to this group. Its asci are cylindrico-clavate or narrow clavate, slightly thickened over the apex, but not capitate, and the ascospores are elongated fusoid, 50–80 × 3–4 μ, hyaline, multiseptate, with strong septa, 5–8 μ apart.

Cordyceps unilateralis (Tul.) Sacc. is another species with similar asci and spores. Mature ascospores in a specimen from British Guiana were about 90 μ long, 3 μ diameter in the middle, tapering to 1 μ diameter at the obtuse tips, multiseptate, with septa about 12 μ apart. In this species, the immature asci are capitate. von Höhnel, who obtained *Cordyceps unilateralis* in Java, described his specimen as a variety, var. *javanica* (*Fragmente zur Mykologie*, No. 210), but from his figure it does not appear to differ in any respect from South American examples of this species. von Höhnel stated that the asci were 220–250 × 8 μ, and the ascospores about 200 × 2·5–3 μ, but from his figure of the apex of the spore cluster, it is evident that the arrangement of the spores was not that of *Cordyceps*, and it would appear probable that an error was made in estimating the length of the spore in the unseparated cluster.

Cordyceps Ridleyi Massee is a form of *C. unilateralis*, in which the plate completely encircles the clava.

Cordyceps peltata Wakefield has fusiform ascospores, multiseptate, 72–91 × 3–3·5 μ, with acute tips. They are often bent in the middle and divide when mature into two halves, but they do not divide into part spores at every septum, as in *Cordyceps* proper.

Cordyceps rhizoidea v. H. has elongated clavate asci, 160–210 × 13–16 μ, which are thick-walled over the apex but have not the typical *Cordyceps* cap. The spores were described as cylindric, acute at the ends, about 80 × 5–7 μ, one-celled. In the last-named particular they do not agree with those of the other species considered here, but von Höhnel stated that his specimen was not quite mature, and it was therefore possible that the spores might develop septa later.

For the above four species, I propose a new genus, *Ophiocordyceps*, with the type species, *Ophiocordyceps Blattae*.

Ophiocordyceps gen. nov. Stroma carnosum, plerumque laeticoloratum, stipitatum, erectum, supra clavatum vel subglobosum. Perithecia stromate immersa vel semi-immersa vel sublibera. Asci clavata, apice incrassata. Sporidia hyalina, fusoidea, multiseptata, asco breviora, non in articulos secedentia.

The species of this genus, known at present, are *Ophiocordyceps Blattae* Petch, *O. unilateralis* (Tul.) Petch, *O. peltata* (Wakef.) Petch, and *O. rhizoidea* (v. H.) Petch.

21. Cordyceps Sherringii Massee

This species, which was collected by R. V. Sherring in Grenada, was described by Massee in *Annals of Botany*, v (1891), 510, as *Cordyceps Sherringii*, not *Sheeringii*, as given in Cooke, *Vegetable Wasps*, etc., and Saccardo, *Sylloge Fungorum*, xi, 366. It grew on an ant.

Massee stated that the clavae sprang from all parts of the body. His figure shows two clavae only, the place of insertion of which is not evident. The type specimen bears two clavae only, and these are on the upper side of the insect, one between the head and the thorax, and the other between the thorax and the abdomen.

Massee figured perithecia with projecting ostiola, and described and figured asci with eight, comparatively short, septate spores, which did not divide into part-spores. Both the clavae on the specimen are immature and do not bear visible ostiola. One of them shows evidence of examination, and in this the perithecia are so immature that they do not contain spores or asci. There is nothing to support Massee's description of the ascospores.

The clavae occur exactly in the same positions as those of *Cordyceps Lloydii*, and their colour and texture are the same as in that species. There does not seem any doubt that the specimen is an immature *Cordyceps Lloydii*.

THE BLACK CANKER OF WILLOWS

By R. W. G. DENNIS

This paper is the outcome of a reinvestigation of the cause of black canker of willows, carried out in the Mycological Laboratory of the University of Bristol during the session 1929–30.

Material was obtained from the willow plantations of the Agricultural and Horticultural Research Station, Long Ashton, and a fungus which proved to be *Physalospora Miyabeana* Fukushi was isolated from diseased twigs obtained there in October, 1929.

During the early part of the period covered, when willow sets in a condition suitable for inoculation were unobtainable, attention was paid to observations on the growth of the fungus in pure culture and its response to environmental factors, in particular to temperature. In the spring of 1930 a series of inoculation experiments on willow sets was carried out.

Black canker of willows has in the past been ascribed usually to the action of *Fusicladium saliciperdum*—"Willow scab"—but few attempts at experimental demonstration of the cause have been made. In the present summary mention is made only of the results of the more recent investigations, especially those in which the problem was approached from the experimental standpoint.

In 1922, Schwarz in Holland gave a detailed account of the disease and associated fungi on *Salix alba* var. *vitellina pendula*. She considered *Fusicladium saliciperdum* as the primary cause of canker but failed to obtain cultures and consequently made no inoculation experiments with it. She mentioned also three fungi as secondary parasites, one of which, *Phoma intricans*, is stated to be a new record. She obtained positive results from inoculation experiments with this fungus and with *Discella carbonacea*. The third parasite was a species of *Physalospora* determined as *P. Salicis* Fuck.

In 1924, Alcock recorded a somewhat similar disease on *Salix alba* var. *vitellina* in Scotland, and she also ascribed it to *Fusicladium saliciperdum*. In 1926, she gave a more detailed description of the symptoms on rods, and described a number of associated fungi including a *Physalospora* identified as *P. gregaria* Sacc.

In 1928, a detailed account of willow canker was published by Nattrass, working at the Long Ashton Agricultural Research Station. He ascribed the disease in Somerset exclusively to a species of *Physalospora* with a *Gloeosporium* conidial stage. This fungus he identified provisionally as *P. Miyabeana* Fukushi. He also isolated *Fusicladium saliciperdum*, apparently for the first time, but obtained only negative results from his inoculations of willows with that fungus.

In 1929, Clinton and McCormick published an account of a similar disease of willows in Connecticut, attributing it to *F. salici-perdum*, on the basis of cultural work and inoculations, and denying the importance of *P. Miyabeana* except as a secondary parasite appearing late in the year.

The present investigation was undertaken with a view to deciding between these conflicting opinions of the cause of willow canker.

Symptoms of the Disease

Conditions in the Bristol district during the summer of 1929 do not appear to have favoured the development of willow canker, which was confined at the Long Ashton plantations to *Salix americana* and its European form "Silicians."

On these willows the symptoms of the disease agreed closely with those described by Schwarz and Nattrass on *Salix alba*.

The first sign of attack is a reddish brown discoloration, usually at the leaf tip, which tends to bend over at right angles. Infection of the middle of the lamina gives rise to similar discoloured areas usually bounded by veins and in the early stages confined to one side of the midrib. Infection through the stipules is rare. Under favourable conditions this discoloration spreads down by way of the petiole to the stem, where brown patches are formed from which cankers develop later. The fungus spreads through the phloem to the cambium which is rendered inactive below the young canker. Subsequent increase in thickness of the rest of the shoot causes a characteristic flattened appearance of the diseased areas, the rind of which shrivels and splits. Extension of the disease in the stem is checked by the formation of a secondary meristem cutting off a layer of cork which isolates the infected area.

Fructifications did not appear in the diseased stems in the field in the 1929 season before the rods were cut, but *Gloeosporium* fructifications of the type described by Nattrass developed on similar diseased stems kept in the laboratory under a bell-jar. Perithecia identified as those of *P. Miyabeana* later appeared in abundance on the same twigs under these conditions.

Isolations were made from conidial pustules and from pieces of infected cortical tissue, all yielding the same fungus which grew readily on malt agar slants (2½ per cent. malt, 2 per cent. agar).

No pustules of a *Fusicladium* were observed on willows, either in the field or under laboratory conditions. The only fungus regularly appearing on the dying leaves was a black saprophytic species of *Cladosporium*. This was observed in abundance on most dead leaves, whether they had been previously infected by the disease in question or not.

Growth of Physalospora Miyabeana in Culture

In general, the observations made by Nattrass on the growth of *P. Miyabeana* in culture have been confirmed. The most favourable temperature for the growth of the mycelium on agar was found to be 25° C. An experiment set up to determine the effect of temperature on the germination of conidia in tap water gave the following results:

Table I. *Percentage germination of conidia*

	15° C.	24° C.	26° C.	30° C.	50° C.
In tap water set 1	92	70	95	10	5
set 2	94	—	97	0	0
In dilute malt extract	—	71	94	—	—

Normally germination takes place by a thin germ tube of varying length which forms a terminal appressorium. At 30° C. the germ tubes are very short and appressoria are not formed. In dilute malt extract germination was abnormal.

Growth of Fusicladium saliciperdum in Culture

As *Fusicladium saliciperdum* fructifications did not appear on any of the willows kept under observation in 1929–30 it was necessary to rely on the isolations of previous workers. A culture of Nattrass's *F. saliciperdum* was obtained from the National Collection of Type Cultures, one of Clinton and McCormick's isolation was kindly forwarded by them from Connecticut, and in the spring of 1930 a culture of *Venturia chlorosporium*, the ascogenous stage of *F. saliciperdum*, was received from Dr Welch of Ithaca, N.Y.

Comparison of the cultures of Nattrass and of Clinton and McCormick showed there was no constant difference in morphology of the fungi or in rate of growth on agar.

On malt agar growth is slow, about $2\frac{1}{2}$ cm. a month at room temperature (15° C.), and the fungus remains almost sterile. Attempts were made to induce more rapid growth and conidial formation by growing the cultures on slightly acid and slightly alkaline malt agar and on other media.

A slight increase in growth rate occurred on acid malt agar, and on Czapek medium growth was a little less rapid than usual. In no case were spores produced. On all media *F. saliciperdum* forms a blackish mat composed of brown, septate hyphae which penetrate deeply into the agar. This becomes covered with a brownish coat of aerial hyphae which always remained sterile. Growth takes place most rapidly at room temperature. At 25° C. it is distinctly slower and at 28° C. ceases completely.

Subcultures on malt agar made from the isolation of *Venturia chlorosporium* supplied by Dr Welch produced a mycelial growth similar to that described above but after one week's growth two-

celled spores of the *Fusicladium* type were produced in abundance. This indicates that the sterility of former cultures was not due to cultivation on an unsuitable medium. Spores derived from the *V. chlorosporium* cultures were set up in hanging drops of tap water to test germination, with the following results.

Table II. *Percentage germinatian of conidia of* Venturia chlorosporium (Fusicladium saliciperdum)

	Room temp. (14° C.)	25° C.	28° C.
Set A	38	10·7	0
Set B	36	10·4	0

At room temperature thin unbranched germ tubes were produced with no appressoria. Only rarely did more than one cell of a spore germinate. At 25° C. germination was poorer and the few germ tubes produced were much shorter than at room temperature. At 28° C. germination failed completely.

Willow Inoculation Experiments

(*a*) *Stems*

On November 18th, 1929, two leafless shoots of *Salix americana* rooting in water were each inoculated twice with *Physalospora Miyabeana* from a monosporous culture in the following way:

A gash was made in the cortical tissue with a sterilised knife and a small piece of agar containing mycelium of the fungus inserted. The wound was then closed and sealed with wax.

Each portion inoculated was then enclosed, together with saturated cotton-wool to keep moist, in a short length of glass tubing plugged at each end with cotton-wool to prevent drying out. Four controls were set up in the same way but with small pieces of sterile agar inserted in place of the culture. After ten days one inoculated portion showed considerable discoloration which after fourteen days had become a definite canker, 1·2 in. long, which was producing the pink conidial pustules of *P. Miyabeana*. At the end of December—one month after inoculation—abundant perithecia of the same fungus were produced.

Four inoculations made in the same way with *Fusicladium saliciperdum* on February 17th, 1930, yielded negative results, but much stress cannot be laid on this, owing to the low proportion of successful stem inoculations with *P. Miyabeana*.

These preliminary experiments can therefore only be held to establish the ability of *P. Miyabeana* to cause a canker, under favourable conditions, when introduced through a wound.

(*b*) *Leaf Inoculations on the Plant*

In these experiments willow shoots growing in pots in a greenhouse were inoculated and enclosed in pieces of glass tubing $1\frac{1}{2} \times 5$–6 in. closed at each end with plugs of cotton-wool. A piece of water-saturated cotton-wool was enclosed with the shoot to keep it moist, and the plant was then placed, unless otherwise stated, in a moist chamber of a warm greenhouse with temperature 25–30° C.

The following set of inoculations, set up on February 27th, 1930, on *Salix vitellina* shoots, may be taken as yielding typical results. Three shoots each had three leaves inoculated with small pieces of agar containing mycelium of Nattrass's *Fusicladium saliciperdum* and were pricked through the middle of the inoculum, on which was placed a drop of water. By March 11th, there was no trace of infection. Failure was not due to drying up, as the leaves were still quite moist.

Three similar shoots had three leaves each inoculated, in the same way at the same time, with *Physalospora Miyabeana* and eight out of the nine leaves showed marked brown discoloration round the puncture at the end of a week. These discolorations increased in size and crossed the midrib but did not extend through the petiole and cause canker before the leaf dropped off.

Six controls with leaves pricked and enclosed as before remained undamaged throughout.

Later experiments show that suspensions of *P. Miyabeana* conidia are capable of causing similar infection of pricked and unpricked leaves, though in the latter infection is naturally slower.

Parallel results have been obtained with *Salix americana* ("Silicians"). Eight inoculations with Clinton and McCormick's *F. saliciperdum* gave no infection after eleven days (March 27th to April 5th, 1930). Nine inoculations of *P. Miyabeana* in the same period gave eight infections. Leaves of *Salix purpurea* inoculated and pricked also gave similar results and *Gloeosporium* conidial pustules appeared on infected leaves after fourteen days. These fructifications on the leaves are of importance, since they agree with Fukushi's description of those produced on leaves of *S. purpurea* var. *angustifolia* in Japan. Nattrass obtained no fructifications on leaves and considered this a point of contrast between his species and that of Fukushi. This distinction is now seen to break down and the identity of the fungi in question is rendered more certain.

Setae were not observed, but the conidiophores appeared stout and nonflexuous, as described by Fukushi. Nattrass found no setae but described the conidiophores as flexuous. It is noteworthy that *Salix purpurea* was the only species investigated which showed fructifications. None was seen on the infected leaves of *S. americana* or *S. vitellina*.

No sign of disease occurred in any of the controls. Owing to the

intolerance of high temperature shown by *F. saliciperdum* all the later series of inoculations were carried out in a cold greenhouse with temperature 10–15° C. Results obtained were perfectly parallel with those outlined above. Infection occurred, though more slowly, with *P. Miyabeana* and no damage was caused by any inoculation with *F. saliciperdum*.

After the receipt of the culture of the *Venturia chlorosporium* stage of *F. saliciperdum*, inoculation experiments were carried out in the cold greenhouse with mycelium and conidial suspensions of the fungus. Negative results were again obtained.

(*c*) *Detached Leaves in Petri Dishes*

It was considered possible that the conditions of the above experiments did not maintain a sufficiently moist atmosphere for active growth and infection by *Fusicladium saliciperdum*. Inoculations were therefore made on March 18th on detached leaves of *Salix vitellina* in Petri dishes containing water-saturated cotton-wool and kept at room temperature.

Of six leaves inoculated with *Physalospora Miyabeana*:

Leaves 1 and 2 had mycelium placed on lower surface and were unpricked.

Leaf 3 as above but pricked.

Leaf 4 had conidial suspension placed on upper surface and pricked.

Leaves 5 and 6 had mycelium placed on upper surface and pricked.

All showed marked infection at the end of a week with the exception of 4, in which infection was doubtful.

Six leaves similarly inoculated with *Fusicladium saliciperdum* mycelium—three on upper surface, three on lower surface—gave negative results, as did six controls.

Discussion

From the above experiments it is concluded that:

(1) *Physalospora Miyabeana* is responsible for black canker of willows, as claimed by Nattrass.

(2) *Fusicladium saliciperdum* under the conditions of the above experiments is incapable of causing any disease of willow leaves, rods or tips.

Clinton and McCormick suggest that Nattrass's failure to obtain positive results from his inoculations with *Fusicladium saliciperdum* was due either to failure to use young tissues or to lack of continued favourable moisture conditions. Young leaves have been the only ones available during the greater part of the time occupied in the above experiments, and sometimes buds just expanding have been inoculated with the *Fusicladium*—still with negative results. There seems no

reason to doubt that the moisture conditions maintained in the tubes used throughout were satisfactory. No signs of drying up were observed at the close of the experiments and in the majority the walls of the tube remained covered with condensed water throughout.

Table III. *Table of inoculations*

1. *Physalospora Miyabeana*

Dates	Inoculum	Temp. ° C.	No. of Inoculations	Place of Inoculation	Willow	Results +	Results −
29. x. 29– 5. xi. 29	Conidia	15	2	Detached leaves	*S. americana*	2	0
18. xi. 29–19. xii. 29	Mycelium	25	4	Stems	,,	1	3
17. ii. 30– 1. iv. 30	,,	25–30	4	,,	,,	0	4
27. ii. 30–11. iii. 30	,,	,,	9	Leaves on growing stem	*S. vitellina*	8	1
3. iii. 30–11. iii. 30	Conidia	,,	3	,,	,,	3	0
6. iii. 30–12. iii. 30	,,	,,	3	,,	,,	2	1
18. iii. 30–24. iii. 30	Mycelium	15	6	Detached leaves	,,	6	0
27. iii. 30– 5. iv. 30	,,	25–30	6	Leaves on growing stem	*S. purpurea*	6	0
27. iii. 30– 5. iv. 30	,,	,,	9	,,	*S. americana*	8	1
11. iv. 30–25. iv. 30	,,	,,	20	,,	,,	18	2
16. iv. 30–12. v. 30	,,	10	3	,,	,,	3	0
		Totals	69			57	12

2. *Fusicladium saliciperdum.*

Dates	Source of inoculum	Inoculum	Temp. ° C.	No. of Inoculations	Place of Inoculation	Willow	Results +	Results −
17. ii. 30– 1. iv. 30	N.	Mycelium	25	4	Stem	*S. americana*	0	4
27. ii. 30–11. iii. 30	N.	,,	25–30	10	Leaves on growing stem	*S. vitellina*	0	10
6. iii. 30– 5. iv. 30	C.	Spores	,,	1	,,	,,	0	1
6. iii. 30– 5. iv. 30	C.	Mycelium	,,	1	Bud	,,	0	1
6. iii. 30– 5. iv. 30	C.	,,	,,	3	Cortex young shoots	,,	0	3
18. iii. 30–24. iii. 30	C.	,,	15	6	Detached leaves	,,	0	6
27. iii. 30– 5. iv. 30	C.	,,	25–30	6	Leaves on growing stem	*S. purpurea*	0	6
27. iii. 30– 5. iv. 30	C.	,,	,,	8	,,	*S. americana*	0	8
27. iii. 30– 5. iv. 30	C.	,,	10–15	4	,,	,,	0	4
16. iv. 30–18. v. 30	W.	,,	,,	10	,,	,,	0	10
5. v. 30–28. v. 30	W.	Spores	,,	6	,,	,,	0	6
		Totals		59			0	59

N. = Nattrass. C. = Clinton and McCormick. W. = Welch.

It was suggested by Nattrass that *F. saliciperdum* was to be regarded as a secondary parasite following infection by *P. Miyabeana*. Experiments show that *F. saliciperdum* will grow slowly on autoclaved willow

leaves, but only slight growth has been obtained in Petri dishes from inoculations of this fungus on diseased areas produced by *P. Miyabeana* on leaves. On similar leaves attached to the plant infection by *F. saliciperdum* has not been obtained.

The results from cultural work show clearly that *F. saliciperdum* grows best at low temperatures and suggest that cold, wet conditions are necessary for successful infection by this fungus. It is believed that these conditions were satisfactorily maintained in the cold greenhouse experiments, but even there no infection by *F. saliciperdum* was recorded.

Just why *F. saliciperdum* has been markedly associated with epidemics of willow canker in Holland, Scotland and U.S.A. is not clear. Its growth on autoclaved leaves may indicate a possibility of its infecting weak and sickly leaves, but against this suggestion must be placed the failure to grow in the laboratory on already diseased leaves. Experiments with sickly leaves have not yet been made. It is possible that the pathogenicity of this fungus may have been lost in culture, or again, that the strains of cultivated willow in Holland and in U.S.A. may differ in susceptibility from those of the corresponding English varieties.

It is noteworthy that Schwarz, Alcock, and Clinton and McCormick all record a species of *Physalospora* parasitic on willow rods and associated with the disease in question, though each gives the species a different name. None of these workers appears to have considered the possibility of a member of this genus being the primary cause of the disease, with the exception of Clinton and McCormick, who record successful inoculations with their species (*P. Miyabeana*) and suggest it is responsible for less serious damage to mature leaves later in the year.

In view of the above experiments this constant association of a species of *Physalospora* with willow canker in England, Scotland, Holland, Japan and U.S.A. seems very significant and supports the opinion previously expressed that a member of the genus is the primary cause of the disease.

Summary

1. This paper records the results of an investigation of the cause of Black Canker of Willows carried out at Bristol University, during the session 1929–30.

2. Growth of *Physalospora Miyabeana* and *Fusicladium saliciperdum* in culture is described and optimum temperatures for growth of each under cultural conditions are indicated.

3. A series of inoculation experiments with the two fungi is described in detail. Positive results were always obtained from

inoculations with *P. Miyabeana* and negative results with *F. saliciperdum.*

4. It is claimed that the disease in question is due to *P. Miyabeana* and that under the conditions of the experiments and in the West of England in general *F. saliciperdum* is in no way responsible for any injury to willow leaves or rods.

I wish to express my thanks to Professor O. V. Darbishire for permission to carry out the investigations in the laboratories of his Department, and to Mr R. W. Marsh for advice and assistance throughout.

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SOME FUNGI ON BRACKEN

By EUPHEMIA C. BARNETT

In the course of investigation into the cause of the "dying back" of bracken much confusion has arisen owing to the number of forms of fungi found on the diseased bracken. *Rhopographus filicinus*, which has long been known as a saprophyte on bracken, has been found constantly. Two pycnidial forms (A and B) were also found—one of these, B, being found on every diseased plant. It was thought that an investigation of these forms would be of interest whether or not the fungi concerned are responsible for the diseased condition of the bracken.

The two pycnidial forms have now been connected with their perfect stages and the details of the life-histories are being investigated.

1. *Rhopographus filicinus*. The black stromata of this fungus are very familiar on the petioles of the bracken. The perithecia are sunk in the stromata and have no definite wall. Ripe ascospores are found in spring (February–March). The spores are large, oval, sometimes slightly curved, 3 or 5 septate, 28–30 × 5–8 μ, yellowish brown.

In the description of the fungus in Saccardo's *Sylloge Fungorum*, it is stated that the spores have hyaline appendages about 6 μ long. We have found no trace of appendages.

Single spore cultures were made on various media. Those on Dox's agar were found to grow most vigorously. There was at first a dense growth of dirty greyish white mycelium. Later a black stroma covered the whole culture. In this stroma pycnidia were developed. The pycnidia were either completely embedded in the stroma or were superficial, when they were provided with a definite black wall. The pycnidiospores were small, hyaline, roundish or oval, measuring 3–4 × 2–3 μ approximately.

2. *Pycnidia* A. In October dead petioles of bracken were examined. They were covered with black stromata like those of *Rhopographus*. On sectioning, these were found to have embedded in them pycnidia with very small roundish-oval spores (3–4 × 3 μ). From the appearance of the pycnidia and their development in stromata like *Rhopographus* it was thought that this was a stage in the life history of that fungus. The development of pycnidia with similar spores in single-spore culture of *Rhopographus* spores confirms this.

3. *Pycnidia* B. The fungus of commonest occurrence on diseased bracken is a pycnidial form (B). Pycnidia are found embedded in the tissue of the fronds, the petioles and the rhizomes. Material brought into the laboratory develops a very dense coating of mycelium and pycnidia are formed freely on these aerial hyphae. The

pycnidia are roundish. They have a distinct ostiole. The wall is at first brown and rather soft, later it becomes black and hard. The pycnidiospores ooze out in worm-like tendrils which are visible to the naked eye. The spores are large, oval, more or less curved, 20–30 × 4–6 μ, hyaline. When young they are unicellular; then uniseptate and later may be 3–4-celled. Occasionally the spores are decidedly thickened at one end. Single-spore cultures have been made and the fungus grows vigorously, especially on Dox's medium, pycnidia being formed in two days. So far no perfect stage has been found in culture.

Bracken, which, so far as could be found, had nothing but this fungus on it, was kept in the laboratory and perithecia developed on it. A perithecium was sterilised in chlorine water, washed in sterile water and dropped on a plate of Dox's agar. In a day or two pycnidia of type B were formed, showing that the perithecial stage is the perfect stage of our B fungus.

The perithecia are of the *Mycosphaerella* type. They have a hard black wall with a distinct ostiole. They are found embedded in the tissues of the host plant. The spores are narrowly oval, tapered at both ends and uniseptate, sometimes slightly curved. So far completely ripe spores have not been found but those which could be measured were about 36 × 4 μ. The perithecia average 140 μ in diameter. Bracken sent from Killin in August 1929 was found to have perithecia with almost ripe spores.

It is concluded that the pycnidial fungi are:

A. Conidial stage of *Rhopographus filicinus*.

B. Conidial stage of a fungus of the *Mycosphaerella* type.

I wish to acknowledge my indebtedness to Mrs N. L. Alcock and Professor K. W. Braid for help and advice.

REVIEWS

Plant Diseases. By F. T. Brooks. Pp. vii + 386, with a frontispiece, and 62 text-figures. London: Oxford University Press. 1928. 21*s.* net.

British plant pathologists have been without an up-to-date text-book of their own since the last edition in 1915 of Massee's *Diseases of Cultivated Plants and Trees*, a work which was useful but not satisfactory. It is true that there have been several books written by Americans, all with their good points and each making a greater or less appeal to individual workers in this country, but it is obvious that though much may be learned from other lands a plant pathologist's country is his own. The main reason why American text-books of plant pathology have a greater vogue here than have continental ones which treat of conditions more like those of this country is mainly that there is less difficulty in understanding their language. Mr F. T. Brooks has attempted to meet the needs of British plant pathologists in the volume under notice. With his experience of lecturing at Cambridge and the directing of research he is especially well qualified for his task. How far he has succeeded in his aim can only show itself with the use of the book. Certainly it contains a vast amount of information, but it is doubtful whether a wholly satisfactory treatment is possible in a volume of this size: from the point of view of presentation it would have been better to have restricted the treatment to diseases important in this country, but the author obviously had in mind the fact that a good proportion of his students are trained for service overseas and wished to give them a general lead. Otherwise one would criticise the small amount of space devoted to the introduction. Plant pathology is a science and requires that its underlying principles and practices should be made plain. The descriptions of lesion and parasite are of the utmost importance and this is up to the standard of previous books, but it is to be regretted that the author has been prevented from expanding some of his introductory paragraphs into chapters and giving us the benefit of his ideas on general theoretical matters. Following the introduction is a chapter on Non-parasitic Diseases and then one on Virus Diseases, and Diseases caused by Bacteria, Actinomyces, Mycetozoa. A short chapter on Classification begins the consideration of Fungi and here the diseases are treated in the order of the parasites, beginning with *Chytridium* and ending with Mycelia Sterilia. A chapter is devoted to *Cephaleuros* and a final chapter to Fungicides. Each chapter has a list of references, and there is a suitable index. The illustrations have as their chief merit that most of them are new; some, however, are of fungi often illustrated, and one or two are not very illuminating.

In a second edition it would be well to drop the comma between the name of the fungus and that of the author—it is not incorrect but it is unnecessary; some of the abbreviations appear strange (e.g. Sade.) and an ampersand in place of "and" would shorten some of the headings; there are also a few slips, but these have probably already been noted. The book is attractively produced and is graced by a photograph of Marshall Ward as a frontispiece. J. R.

The Spore-Ornamentation of the Russulas. By Richard Crawshay. Pp. vi + 179, 46 plates, 21 figures (2 colour charts). London: Baillière, Tindall & Cox. 12*s.* 6*d.*

The work under review is one of those which at first sight gives a feeling like that experienced by the countryman when he first saw a giraffe. Few who use a microscope have not been impressed by certain slight but constant differences in the spores of closely allied species: the difference in size has doubtless been over-

emphasised, but there is usually something more subtle which is not so easy to express. There is occasionally a well-marked difference in the markings on the spore membranes, and this has been noted particularly in Discomycetes where not only generic differences are obvious in the type of spore markings but specific differences also.

Among Basidiomycetes certain spores are characteristic but, generally speaking, *Lycoperdon* is about the only genus where the spores seem obviously distinct. René Maire in his *Les bases de la classification dans le genre Russula* in 1910, pointed out the use that can be made of the spore characters in this genus, and most mycologists have been content to make the same general use of these. Crawshay, however, has carried the matter much further and maintains that it is possible by relying almost wholly on the microscopic character of the spores to distinguish between the various species. "The microscopic study of the spores... affords us a practical, and provided we have some very limited information concerning the particular species under examination, an almost infallible method of determination. The information here referred to may be limited preferably to the colour of the spore deposit and to some characteristic of the plant, such as the taste (mild or peppery) or the colour of the cap." The author gives full details about his microscopical methods. Following on this is a dichotomous key to the species, the main divisions being "taste mild" and "taste peppery," and three subdivisions according to the colour of the gills, a a colour chart being provided to illustrate the colours. Next is a chapter headed "Notes" which gives varied information about several species. There follows a chart with eight colours to represent spore deposits. The remainder of the book consists of 46 plates, giving 137 drawings of spore fields magnified 1790 diameters: the spores were first fixed to the slide by an albumen fixative and immersed in a solution of iodine in potassium iodide.

When Mr Crawshay first showed me his drawings I was impressed with the care and skill which had obviously been expended on them, but was somewhat doubtful of their scientific value. I have examined spores by his method and have found that his drawings represent what is to be seen. So far I have not been able to use his scheme in the way in which he himself is able to do and name a species from a spore deposit. Mr Crawshay has presented the drawings of the fungi from which the spore deposits were made to the Department of Botany of the British Museum, and thus it is possible to know the fungus he had under examination. The determinations follow closely those of Bataille (who provides a preface), but it is certain that we are still far from general agreement both as to what constitutes a species of the genus *Russula* and what its name is to be when defined. One new species, *R. brunneoviolaceus*, is described and is assumed to be that figured by Cooke as "*R. purpurea* Gill."

The author shows a pleasing confidence in his determinations, and though in some of these he will certainly not be followed he is to be congratulated on having suggested a new method of attack on one of the most difficult systematic problems.

J. R.